DESIGN OF A 19 INCH SOLID-STATE TELEVISION RECEIVER (EXCLUDING THE DEFLECTION AND VIDEO PROCESSING CIRCUITS)

A Thesis Submitted
In Partial Fulfilment of the Requirements
for the Degree of
MASTER OF TECHNOLOGY

by
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to the

Department of Electrical Engineering
Indian Institute of Technology Kanpur
August 1972

CERTIFICATE

This is to certify that the thesis entitled "Design of a 19 inch solid-state Television Receiver (Excluding the deflection and video processing circuits)" is a record of the work carried under my supervision and that it has not been submitted elsewhere for a degree.

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5.9.72

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S.N.ZINDAL

C O N T E N T S

ABSTRACT

The design of a solid-state T.V.receiver (excluding the deflection and the video processing circuits) has been undertaken. The design is according to the C.C.I.R. recommendations and the standards laid down by I.S.I.

The tuner and the video I.F. amplifier have been designed and fabricated using the IC CA 3028A. IC TAA 570 has been used for the S.I.F. amplifier and the discriminator.

CHAPTER 1

SYSTEM DESIGN

1.1 Introduction

The first transistorised receiver appeared in 1952, just 4 years after the invention of transistors. This was followed by Philco's 'Safari' and Motorola's 'Astronaut' in 1959 and 1960 respectively. Both were light-weight, directly viewed, battery supplied and had performance similar to the valve receivers. Japanse in 1962 developed an ultra-small model 'Micro-TV' about the same size as a Telephone hand set and weighing only 6 lbs.

The development of transistorised receivers was however slow because of some technical problems. The transistorised large screen sets produced now compare favourably with the valve version. Both provide pictures of same brightness, have similar sensitivities and sound outputs. The transistorised receivers have the added advantage of requiring low power, having longer life and are portable. Further, with the introduction of integrated circuits the cost of the receiver will be reduced and it will have greater reliability. In India, the design and development of the solid-state receiver

has of late received great encouragement because of the increased availability of the solid-state devices.

In the year 1970, the work was initiated here in this direction and a report was presented last year entitled 'Design of a 19 inch solid-state Television Receiver (system design and stages after the second detector)'[1]. The work reported here is an extension of the above. The aim of this project was to design and fabricate the following stages of the receiver.

1. Tuner
2. Video I.F.Amplifier
3. A.M. Detector
4. A.G.C.Circuits
5. Sound I.F.Amplifier
6. Discriminator
7. Audio Amplifier

The design specifications for these stages are determined so as to meet the recommendations of CCIR (International Radio Consultative Committee), for the TV transmission system in India.[3] The system design also takes into account the standards for monochrome television reception in India, laid down by I.S.I. (Indian Standards Institution).[4] Finally, availability of Indian components has also influenced the design.

1.21 The TV system specifications and the receiver minimum requirements

The main relevant recommendations of CCIR and standards of ISI are as follows:

1. Nominal video bandwidth = 5 MHz
2. Nominal radio frequency bandwidth = 7 MHz
3. Sound carrier relative to vision carrier = + 5.5 MHz
4. Sound system: f.m. bandwidth = 50 KHz
5. Frequency characteristics for the vestegial side band transmission is shown in Fig.1.1

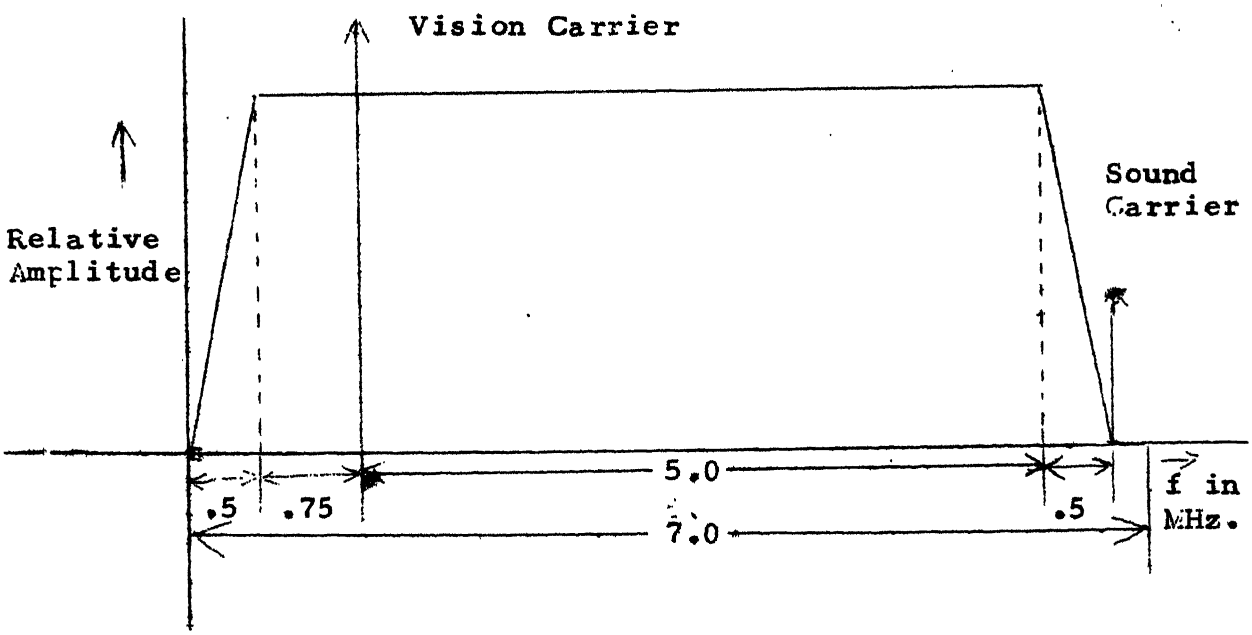


Fig. 1.1 V.S.B.frequency characteristics of T.V. transmission in India (as recommended by C.C.I.R.)

Vision section

6. Noise limited sensitivity- Better than 300 μV for a S/N ratio of not less than 30 dB at the picture tube.

7. Synchronizing sensitivity- Better than 50 μV

8. Automatic gain characteristics- The signal at the picture tube not to vary more than 6 dB for a variation in input television signal from 300 μV to 100 mV.

9. Selectivity- The RF pass band shall be such that:

   a) The 6 dB bandwidth of the complete IF amplifier measured between mixer and the detector is not less than 4.5 MHz.

   b) The sound carrier is attenuated by at least 25 dB

   c) Picture carrier of higher adjacent channel and sound carrier of lower adjacent channel are to be suppressed by at least 40 dB.

10. IF interference ratio- Better than 60 dB.

11. Image interference ratio- Better than 60 dB

12. Radiation- Not to exceed 400 μV/meter at a distance of 3 meters

Sound section

13. Output power- Not less than 1 watt

14. Noise limited sensitivity- Better than 100 μV for S/N ratio of not less than 30 dB.

15. A.M. suppression ratio- Better than 40 dB.

16. Hum- At least 40 dB below maximum audio output level.

17. Spurious response ratio- Better than 40 dB.

1.22 The receiver performance specifications

1. Noise figure of the receiver: Because of the limited power of the transmitter at V.H.F. and because of desirability of obtaining satisfactory reception in the fringe areas, the noise-figure of the receiver is very important. Receiver noise-figure of 9 dB is a realistic value that can be obtained in low priced mass produced receivers.

2. Sensitivity of the receiver: The minimum power gain desirable in the tuner is 30 dB. This value is a compromise between the noise-figure and stability considerations. The required overall gain from a video I.F. amplifier (i.e. after accounting for circuit losses due to traps and coupling networks) of 55 dB is easily attainable. The total gain from antenna up to A.M. detector is 85 dB. We need 1 volt d.c. across a detector load of 3.3 K ohms for a good picture and sound reception.

Therefore the input power to antenna

$$= \frac{1^2/3.3\times10^3}{\text{Antilog } 85/10}$$

$$= \frac{303\times10^{-6}}{3.16\times10^{8}}$$

= 0.96 picowatts

The receiver sensitivity for a 300 ohms antenna would be approximately 17 microvolts.

3. Overall frequency response of the receiver: The ideal frequency response of the receiver, for the vestigial sideband transmission system is shown in Fig. 1.2

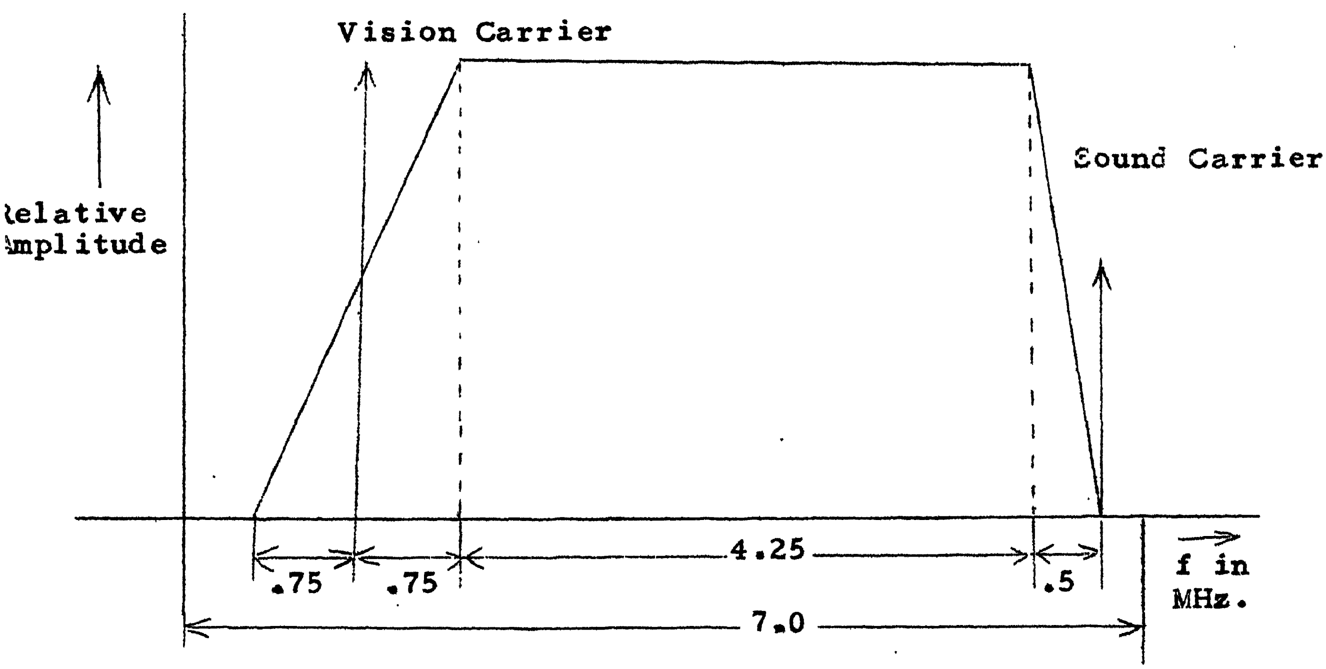
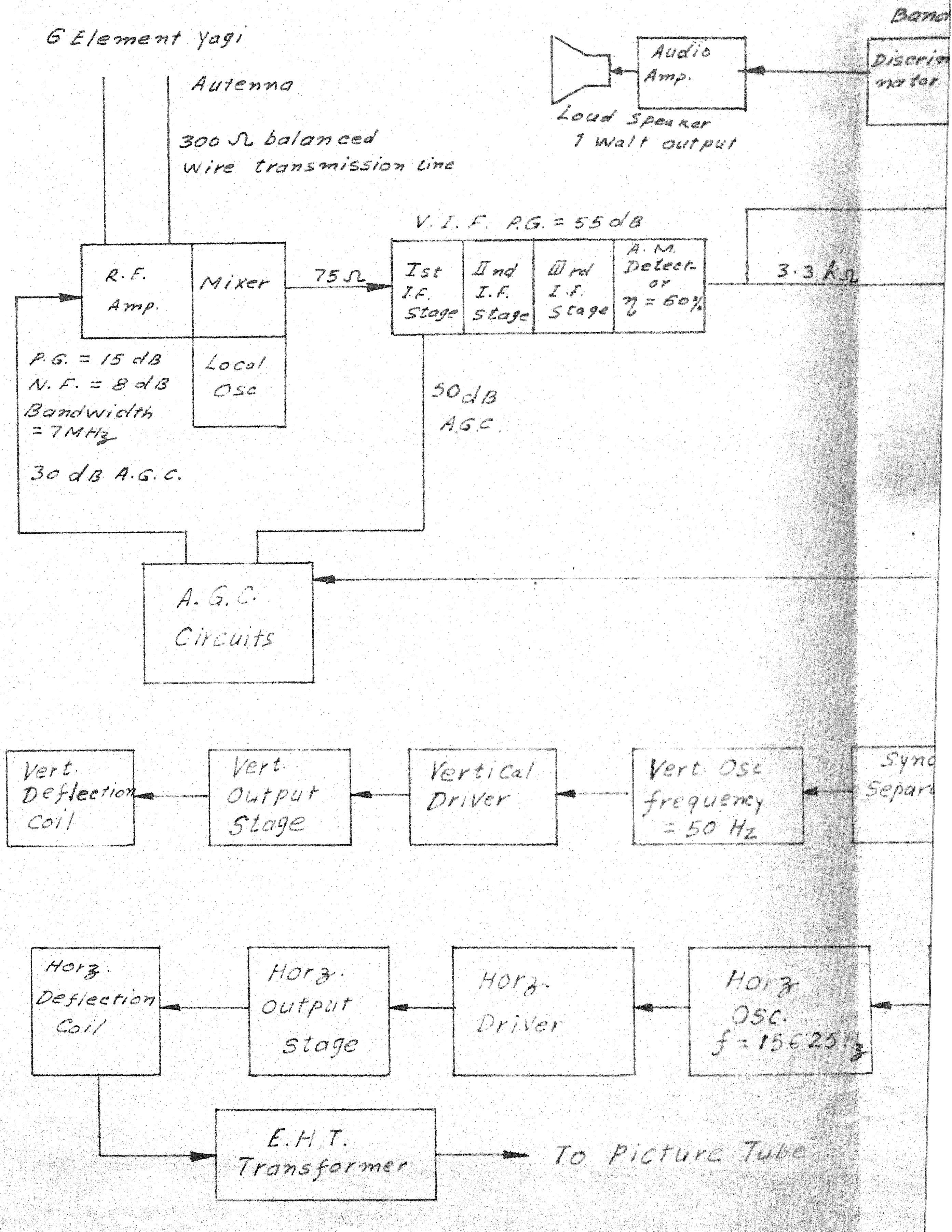
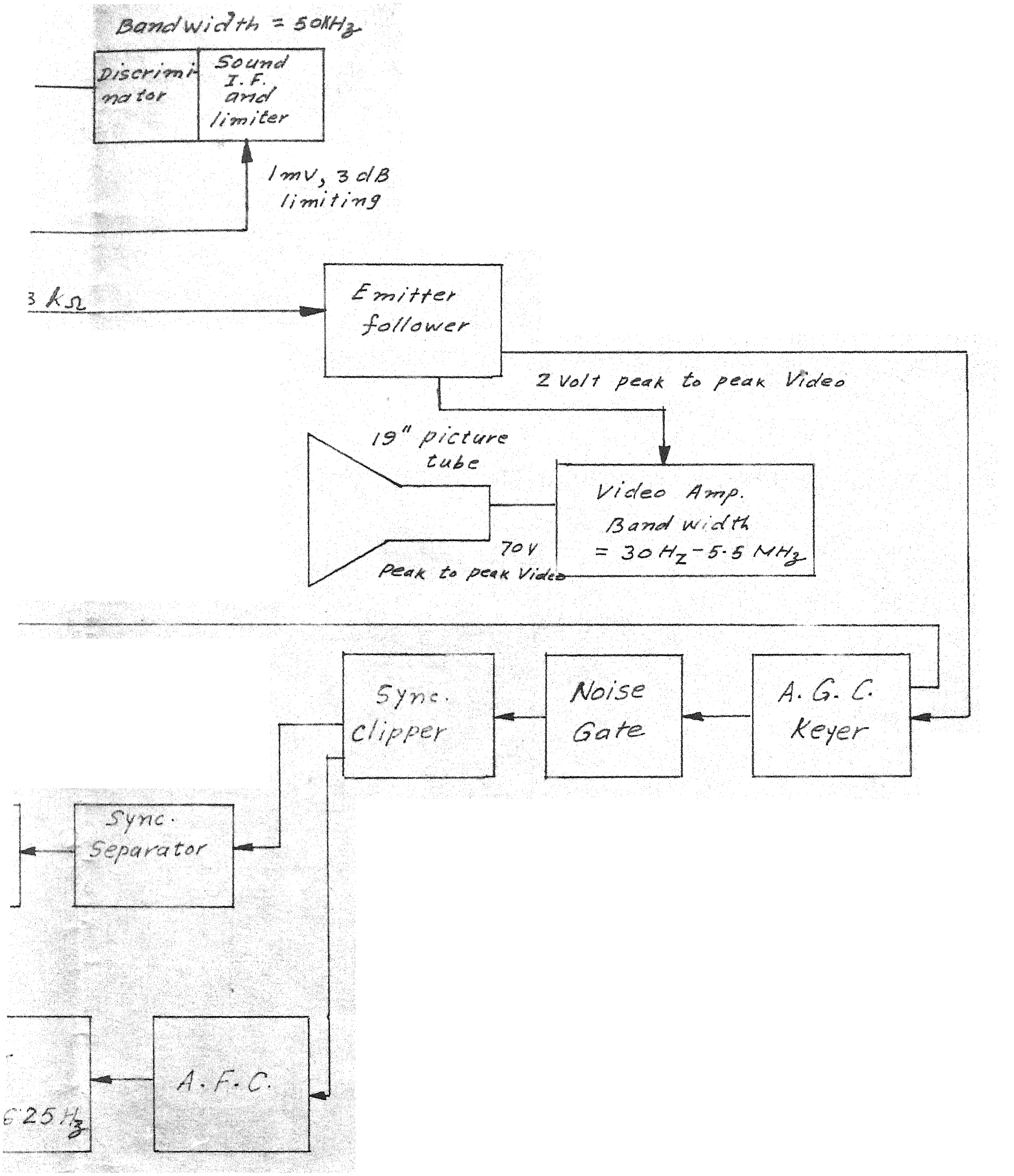


Fig. 1.2 Ideal frequency response characteristics of the T.V. receiver for the V.S.B. transmission system.



6 Element Yagi
Autenna
300 Ω balanced
wire transmission line
Audio Amp.
Loud Speaker
1 Watt output
Discriminator
V. I. F. P.G. = 55 dB
R.F. Amp.
Mixer
75 Ω
Ist I.F. Stage
IInd I.F. Stage
IIIrd I.F. Stage
A.M. Detector
η = 60%
3.3 kΩ
P.G. = 15 dB
N.F. = 8 dB
Bandwidth = 7MHz
30 dB A.G.C.
Local Osc
50 dB A.G.C.
A.G.C. Circuits
Vert. Deflection Coil
Vert. Output Stage
Vertical Driver
Vert. Osc frequency = 50 Hz
Horz. Deflection Coil
Horz. Output stage
Horz. Driver
Horz. Osc. f = 15625 Hz
E.H.T. Transformer
To Picture Tube


Bandwidth = 50kHz
Discriminator
Sound I.F. and limiter
1mV, 3 dB limiting
3 kΩ
Emitter follower
2 Volt peak to peak Video
19" picture tube
Video Amp. Band width = 30 Hz - 5.5 MHz
70V Peak to peak Video
Sync. Clipper
Noise Gate
A. G. C. Keyer
Sync. Separator
A. F. C.
625 Hz

4. Local oscillator stability: For ± 10% fluctuation in line voltage = ± 50 KHz.

5. The stages are to be designed for 4th channel (vision carrier = 62.25 MHz, sound carrier = 67.75 MHz.).

1.31 The block diagram

The block diagram of the receiver is shown in Fig.1.3. The design specifications for these stages are set by the considerations given in 1.21.

1.32 Subsystem design

1.321 The tuner- This includes V.H.F. antenna (with the arrangement of connecting it to input of the R.F. amplifier), R.F. amplifier, local oscillator and the mixer.

1.3211 The antenna and the transmission line- The six element Yagi antenna provides high gain (nearly 15 dB) and directivity over a relatively narrow band and is quite useful for single channel receiver.

The distance involved in connecting the antenna terminals to the receiver input makes the use of low-loss transmission line important. Low impedance coaxial line has been used and has relatively low loss. But, this is expensive for receiver installation, and, furthermore, requires some form of balun for proper matching to a balanced antenna. Instead a balanced parallel wire

transmission line, with the characteristic impedance equal to the antenna impedance (300 ohms) can be used, eliminating the need of the balun.

1.3212 The R.F. amplifier: The necessity of having a superheterodyne type of receiver is very well established. Furthermore, to achieve a low noise-figure and good image frequency rejection ratio, a R.F. amplifier has to be used.

The following specifications are to be met for the R.F. amplifier stage:

Power gain = 15 dB

Noise-figure= 8 dB (for the mixer noise-figure = 10 dB, this gives receiver noise-figure= 9 dB)

A.G.C. range= 30 dB

Amplifier bandwidth = 7 MHz.

1.3213 The local oscillator: The following are the considerations in designing of the local oscillator:-

1. The temperature stability factor S=2 assures good temperature stability,

2. Local oscillator is tuned to a frequency higher than that of the picture carrier. This minimises the effect of the image frequency and other spurious frequencies and also the tuning range is increased.

3. The injection power should be such as to give maximum conversion gain, minimum distortion and minimum oscillator radiations. An injection power of about 300 microwatts and a frequency stability of $\pm$ 50 KHz is required.

1.3214 The mixer

The following are the specifications for the mixer:-

1. Conversion gain = 20 dB.
2. Mixer bandwidth = 7 MHz.
3. Noise-figure = 10 dB.
4. I.F. frequency = 38.9 MHz (picture carrier)

1.3222 The video I.F. amplifier and the detector

1.3221 I.F. stage: Most of the power gain of the receiver is obtained in this stage. The required frequency response of the receiver is also obtained in this stage. The specifications for this stage are as follows:-

1. Power gain of I.F. stage = 55 dB.
2. The I.F. bandpass characteristics should be as shown in Fig. 1.4. Reversal of the position of sound carrier w.r.t. vision carrier occurs because of tuning the local oscillator to a frequency higher than that of the vision carrier.

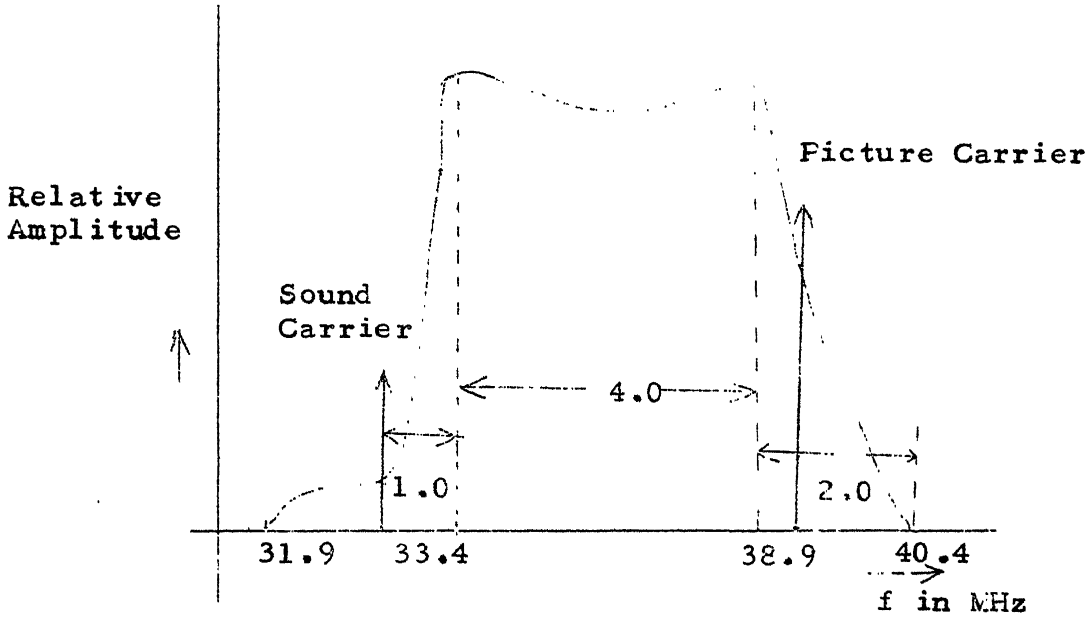


Fig. 1.4 Response of the V.I.F. amplifier

3. A.G.C. range = 50 dB

1.3222 A.M.detector: The output of the final I.F. stage is fed in to the A.M. detector. The output of the detector should be 1 volt d.c. (more than 2 volt peak to peak video with negative going sync. polarity).Specifications for the detector are:-

1. Efficiency = 60%
2. Output impedance = 3.3 K ohms
3. Frequency response of the detector output circuit should be wide enough to include 5.5 MHz sound carrier signal.

1.323 The sound circuits: The S.I.F. amplifier, the discriminator and the audio amplifier.

The intercarrier type of sound system, in which sound is taken after the vision detector was selected. In this type of system satisfactory sound reception does not depend critically on a highly stable local oscillator frequency.

As indicated earlier, the sound carrier must be attenuated in comparision to the vision carrier (see figure 1.4). The height of the flat portion in vicinity of sound carrier should be comparable with the minimum level ever attained by the vision carrier. This is essential for good A.M. rejection and limiting in sound I.F. stage.

Specifications:

1. The prime requirement of the sound I.F. amplifier is to amplitude limit with as small a signal as practical. For quantitative analysis a term 'Limiting sensitivity' is defined as that signal level at which the output power has fallen three decibles below maximum. This condition is referred to as '3-dB limiting'. A desirable sensitivity for a 3-dB limiting is 1 mV rms at the input of the system.

2. Minimum bandwidth of detector and I.F. stage = 50 KHz (This is minimum frequency deviation for 100% modulation).

3. A.M. rejection ratio should be better than 40 dB.

4. 1 watt of audio output at maximum volume.

1.324 The A.G.C. circuits

The A.G.C. figure-of-merit is described as the number of dB reduction in the input signal, below 100,000 microvolts, required to reduce the picture output voltage by 10 dB. This is also known as the dynamic range of the A.G.C.

Thus from the sensitivity specified for the receiver (17 microvolts), we conclude that for a maximum input signal of 100 mV, the overall A.G.C. capability should be 76 dB. This A.G.C. range can be obtained by applying A.G.C. to the first stage of V.I.F. amplifier and to the R.F. stage.

The figure-of-merit for this A.G.C. capability is expected to be better than a normally specified value of 60 dB.

CHAPTER 2

THE TUNER

2.1 The R.F.amplifier- The requirements of the R.F. amplifier are:

Power gain = 15 dB

Noise-figure = 8 dB

A.G.C. range = 30 dB

Amplifier bandwidth = 7 MHz

Integrated circuit module CA 3028A has been used for the R.F. amplifier and other stages of the tuner and the V.I.F. amplifier. The details about the capabilities, limitations and performance data are given in Appendix I.

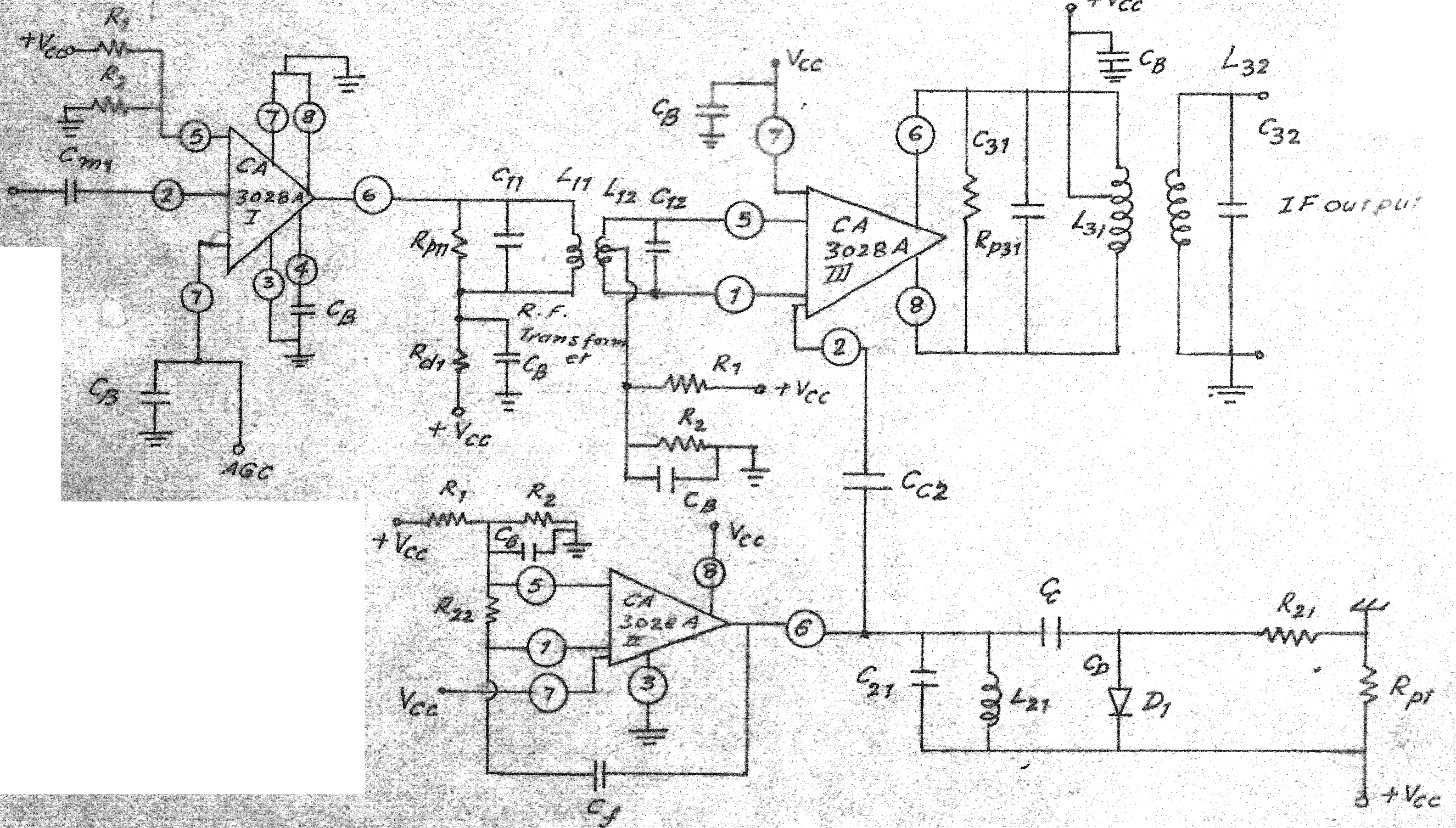
The CA 3028A is a differential amplifier with a constant current source. This can be used as a R.F. amplifier either in the cascode mode or in the differential mode.

2.11 Amplifier design

For R.F. amplifier the IC has been used in the cascode mode. The complete circuit diagram of the tuner is shown in Fig. 2.1.

At 65 MHz the input admittance of the first stage is given by

$$y_{11} = (5+j4.1)\text{mmhos}$$



$R_1 = 1\ K\Omega$	$R_{21} = 56\ K\Omega$	$L_{11} = 0{\cdot}60\ \mu H$	$C_{11} = 1{\cdot}5\ PF$	$C_{m1} = 47\ p$
$R_2 = 2\ K\Omega$	$R_{pt} = 10\ K\Omega$	$L_{12} = 0{\cdot}22\ \mu H$	$C_{12} = 12\ PF$	$C_{C2} = 33\ p$
$R_{d1} = 100\ \Omega$	$R_{22} = 330\ \Omega$	$L_{21} = 0{\cdot}1\ \mu H$	$C_{21} = 8{\cdot}2\ PF$	$C_f = 18\ p$
$R_{p11} = 2\ K\Omega$	$C_B = 1500\ pF$	$L_{31} = 1{\cdot}33\ \mu H$	$C_{31} = 15\ PF$	$V_{cc} = 9\ V$
$R_{p31} = 5.5\ K\Omega$	$C_c = 1500\ PF$	$L_{32} = {\cdot}034\ \mu H$	$C_{32} = 470\ PF$	

FIG. 2.1 THE TUNER CIRCUIT DIAGRAM

therefore, R_{in} = 200 ohms and C_{in} = 10 pF

At the input of the tuner, a 300 ohms twin wire line will be coming from the tuner, therefore for matching the impedance levels, the capacitor C_{m1} will be calculated from the equation:

$$200\left(\frac{C_{m1}+10}{C_{m1}}\right)^2 = 300 \quad (C_{m1} \text{ in pF})$$

or C_{m1} = 44 pF.

C_{m1} is selected to be 47 pF.

The primary and the secondary of the R.F. transformer are tuned at 63.5 MHz and 66.5 MHz respectively. Both have a bandwidth of about 6 MHz. This will give a R.F. response as shown in Fig. 2.2

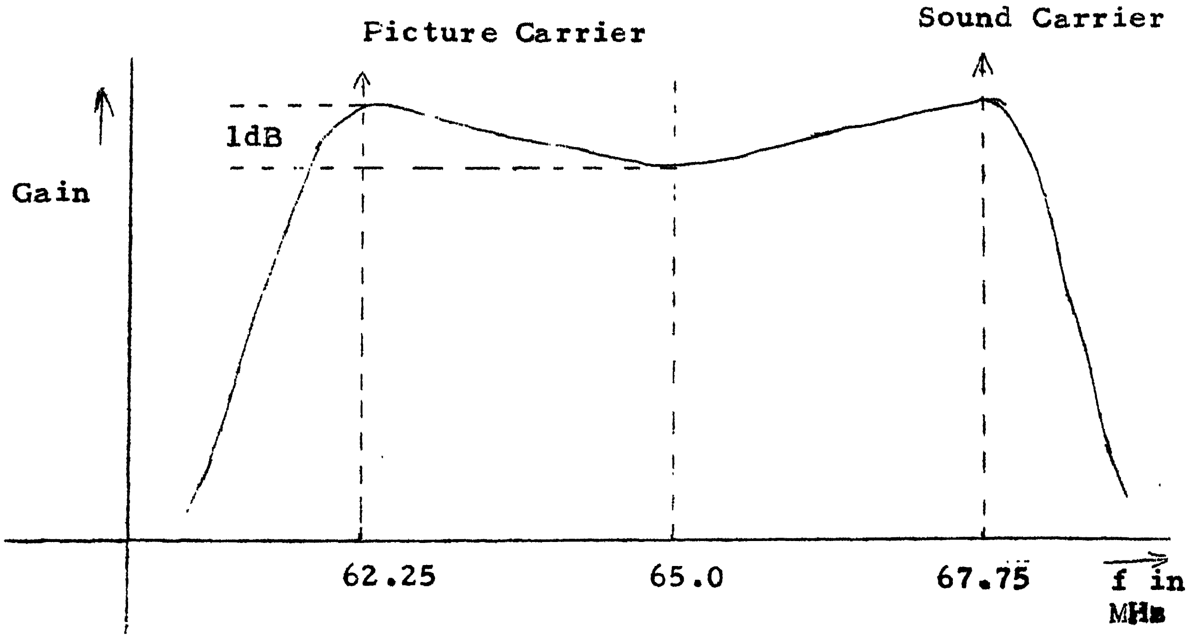


Fig. 2.2 The mixer driver transformer response curve.

Thus $Q_{Lp} = 63.5/6 = 10.6$

and $Q_{Ls} = 66.5/6 = 11.1$

The primary and the secondary loads are selected to be 2.5K ohms and 1 K ohms respectively. The secondary load is limited by the input resistance of the mixer itself.

The primary inductance

$$L_{11} = \frac{R_p}{w\, Q_L} = \frac{2.5\text{x}10^3}{2\text{x}3.14\text{x}63.5\text{x}10^6\text{x}10.6}$$

$$= 0.6\ \mu\text{H}$$

The capacitance required for the tuning is

$C_T = 10.5$ pF.

The output admittance of the first stage is given as $y_{22} = (-0.035 + j\ 1.6)$mmhos

This gives $R_{out} = -\ 28.6$ K ohms

and $C_{out} = 4$ pF.

The external capacitance required is 6.5 pF. But the actual capacitance required for tuning is 1.5 pF.

For a unloaded Q of 50, the self resistance of the inductance L_{11}

$R_U = wLQ_U = 12$ K ohms

Now, $R_T = R_{p11} \,||\, R_U \,||\, R_{out} = 2.5$ K ohms

This gives $R_{p11} = 3.2$ K ohms

It has been found experimentally that a value of 2 K ohms gives the required shape.

The biasing resistors R_1 and R_2 are 1Kohms and 2Kohms respectively. The bypass capacitors are of value 1500 pF.

2.12 A.C. stability

At 65.0 MHz

g_{11} = 5.0 mmhos

g_{22} = -0.037 mmhos

y_{12} = (0.01 - j0.007)mmhos

y_{21} = (.65-j60)mmhos

The Stern's stability criterion requires k to be greater than one for the stability in the following equation

$$(g_{11}+G_g)\ (g_{22}+G_L) = \frac{k(L+M)}{2}$$

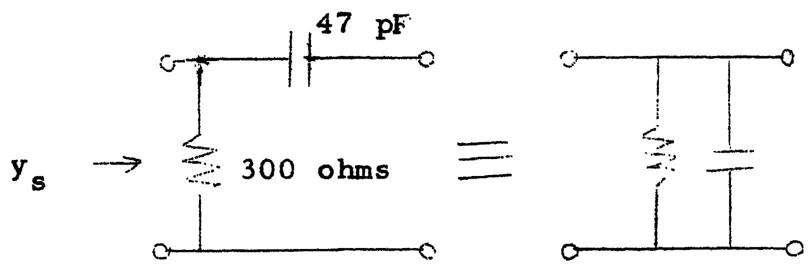
where, G_g = real part of the source admittance

G_L = real part of the load admittance

$L = \left| y_{12}\ y_{21} \right|$

M = real part of $(y_{12}\ y_{21})$

The source admittance is calculated from the following circuit



$$y_s = 1/Z_s = 1/(R+1/jwC)$$

$$= \frac{jwC}{1+jwRC} = (3.24+j0.56)\text{mmhos}$$

$$\therefore \quad G_g = 3.24\text{mmhos}$$

$$G_L = 1/R_p = 0.4\text{mmhos}$$

$$y_{12}\, y_{21} = (.23-j1.055)\ \mu\ \text{mhos}^2$$

$$M = 0.23\ \mu\text{mhos}^2$$

$$L = 1.08\ \mu\text{mhos}^2$$

$$\therefore \quad k = \frac{2(g_{11}+G_g)(g_{22}+G_L)}{L+M}$$

$$= 4.56$$

Thus the stage is stable

2.2 The local oscillator

The terminals 1 and 5 of the local oscillator stage (II stage, Fig. 2.1) are to be biased at the same potential for a good balanced operation. But for the R.F. signal there should be high impedance path between them. This is achieved by putting a R_{22} of 330 ohms

between them. The d.c. drop across the resistance will be about, 6.6 mV for a bias current of 20 μA (Appendix I). For the local oscillator signal, it will act as a very high impedance path in comparision to 1 ohm path of the bypass capacitor.

The input and output admittances of the local oscillator at the frequency of 101.15 MHz are given by

$$y_{11} = (1.1+j1.3)\text{mmhos}$$

and $$y_{22} = (0.3+j1.0)\text{mmhos}$$

$$\therefore \quad R_{in} = 900 \text{ ohms}, \quad C_{in} = 2.1 \text{ pF},$$

$$R_{out} = 3.3\text{kohms and } C_{out} = 1.62 \text{ pF}$$

The input admittance at the terminal 2 of the mixer is

$$y_{11} = (6.2+j4)\text{mmhos}$$

$$\therefore \quad R_{in} = 161 \text{ ohms and } C_{in} = 6.5 \text{ pF}.$$

The power delivered by the local oscillator to the mixer should be between 0.1 and 1.0 mwatts. This value gives a good compromise between the mixer gain and the noise. The greater injection can cause the detuning of the mixer output tuned circuit by changing the d.c. bias current in terminals 6 and 8 of the IC. The d.c. current change may be sufficient to change the output admittance y_{22}.

Since the mixer input resistance is 161 ohms at the local oscillator frequency, the peak to peak voltage required at the input of the mixer for a power of 0.3 mwatts is

$$V_{pp}^{2} = 8xRxP=8x161x0.3x10^{-6} =.386$$

or $V_{pp} = 623$ mV.

The feedback capacitance C_f is selected of value 18pF and coupling capacitor C_{c2} of value 33 pF. The inductance L_{21} is 0.1 μH.

The total capacitance for tuning L_{21} at 101.15 MHz C_T = 26pF

Now, $C_T = C_D + C_{21} + C_{outL.0.} + C_f$ inseries with $C_{inL.0.}$

$+ C_{c2}$ in series with $C_{in\ mixer}$.

$C_{outL.0.}$=1.62pF.

C_f series $C_{inL.0.}$ = (18pF) series (2.1pF) = 1.88pF

C_{c2} series $C_{in\ mixer}$ = (33pF) series (6.5pF)

= 5.44 pF.

For fine tuning a bandwidth of 4MHz is enough. This will require a capacitance variation of about 2.2pF. Diode TIV 303 has a variation in capacitance from 6pF to 13pF for a change in voltage of about 15 volts.

The capacitance is varied from 6pF to 9pF in this circuit. Therefore, the mean value C_D = 7.5pF.

$\therefore$ C_{21} = 26-7.5-1.62-1.88-5.44 = 9.56pF.

A 8.2 pF capacitance is put as C_{21}. For the diode circuit a resistance R_{21} of 56Kohms and a potentiometer R_{pt} of 10Kohms is used.

For biasing R_1 and R_2 are of value 1Kohms and 2Kohms respectively. All by-pass capacitors are of value 1500 pF.

2.3 The mixer

The main factors which must be considred in designing the mixer are the following:

(a) frequency requirements

(b) the configuration of the mixer

(c) d.c. biasing, and

(d) coupling to R.F. oscillator and I.F. stages.

The mixer stage has to handle many frequencies besides the carrier and local oscillator signals at the input, and the I.F. signal at the output. Typical of these additional signals are the local oscillator second harmonic and image frequencies.

2.31 The mixer design

The input admittance of the mixer for the frequency of 66.5 MHz is given as

$$y_{11} = (0.8+j1.95)\text{mmhos}$$

This gives, R_{in} = 1.25Kohms and C_{in} = 4.65 pF

The load for the secondary was selected to be 1kohms. The self resistance of the coil for a unloaded Q of 50 and a band width of 6MHz is

$$R_U = R_p \times Q_U / Q_L \qquad (Q_L = 66.5/6 = 11.1)$$

$$= 1\text{x}10^3\text{x}50/11.1 = 4.5\text{Kohms}$$

This R_U in parallel with R_{in} of the mixer gives a load of 980 ohms. Thus there is no need of putting an external load.

Now, $L_{12} = R_p/(wQ_L)$

$$= \frac{1\text{x}10^3}{2\text{x}3.14\text{x}66.5\text{x}10^6\text{x}11.1} = 0.218\ \mu H$$

The total tuning capacitor required is 26pF. Thus the external capacitance put should be about 21pF. But actually only 12pF capacitance is required. The difference is partly due to parasitic and coil capacitance and partly due to some reflected capacitance from the input of the mixer of local oscillator frequency terminal.

At the output of the mixer, a double tuned, inductive coupled circuit has been used. The output admittance of the mixer at the central I.F. frequency 36MHz is given as $y_{22} = (0.135+j0.5)$mmhos

This gives , $R_{out} = 7.4$Kohms and $C_{out} = 2.2$pF.

The primary and the secondary of the tuned circuit are tuned at 34.5 MHz and 37.5MHz respectively. The primary load is 2.5Kohms and the secondary load is 75 ohms, the cable impedance. The bandwidths are 4MHz each.

$$\therefore \quad Q_{Lp} = 34.5/4 = 8.625 \text{ and ,}$$

$$Q_{Ls} = 37.5/4 = 9.375$$

Therefore, $$L_{31} = \frac{2.5x10^3}{2x3.14x34.5.10^6x8.625} = 1.33\ \mu H$$

The tuning capacitor required is 16.2pF. The external tuning capacitor required is 14pF. A 15pF capacitance is selected as C_{31}.

To find out the external load impedance, the self resistance of the coil is

$$R_U = R_p \times Q_U/Q_L$$

$$= 2.5x10^3x50/8.625 \qquad (Q_U=50)$$

$$= 14.5\text{Kohms}$$

Now, $R_T = R_U \parallel R_{out} \parallel R_{31} = 2.5$ Kohms

$\therefore R_{31} = 5.13$ Kohms

A resistance value of 5.5Kohms is selected.

The secondary inductance L_{32} is

$$L_{32} = \frac{75}{2 \times 3.14 \times 37.5 \times 10^{6} \times 9.375}$$

$$= 0.034\ \mu H$$

The tuning capacitance required is 535 pF. A 470pF capacitor is used.

2.32 Mixer a.c. stability

In case of the mixer , the two input frequencies and the output frequency are all different from each other. Hence the question of feedback and the accompanying problem of instability does not arise.

2.4 Packaging

The packaging of the tuner in VHF band is very important. The proper grounding and shielding are very important. All the coils should be shielded, the shield should be properly grounded at least at two points. Apart from this the whole tuner should be enclosed in a box, the box being grounded. In addition, the R.F. stage and the local oscillator stage should be separated by a

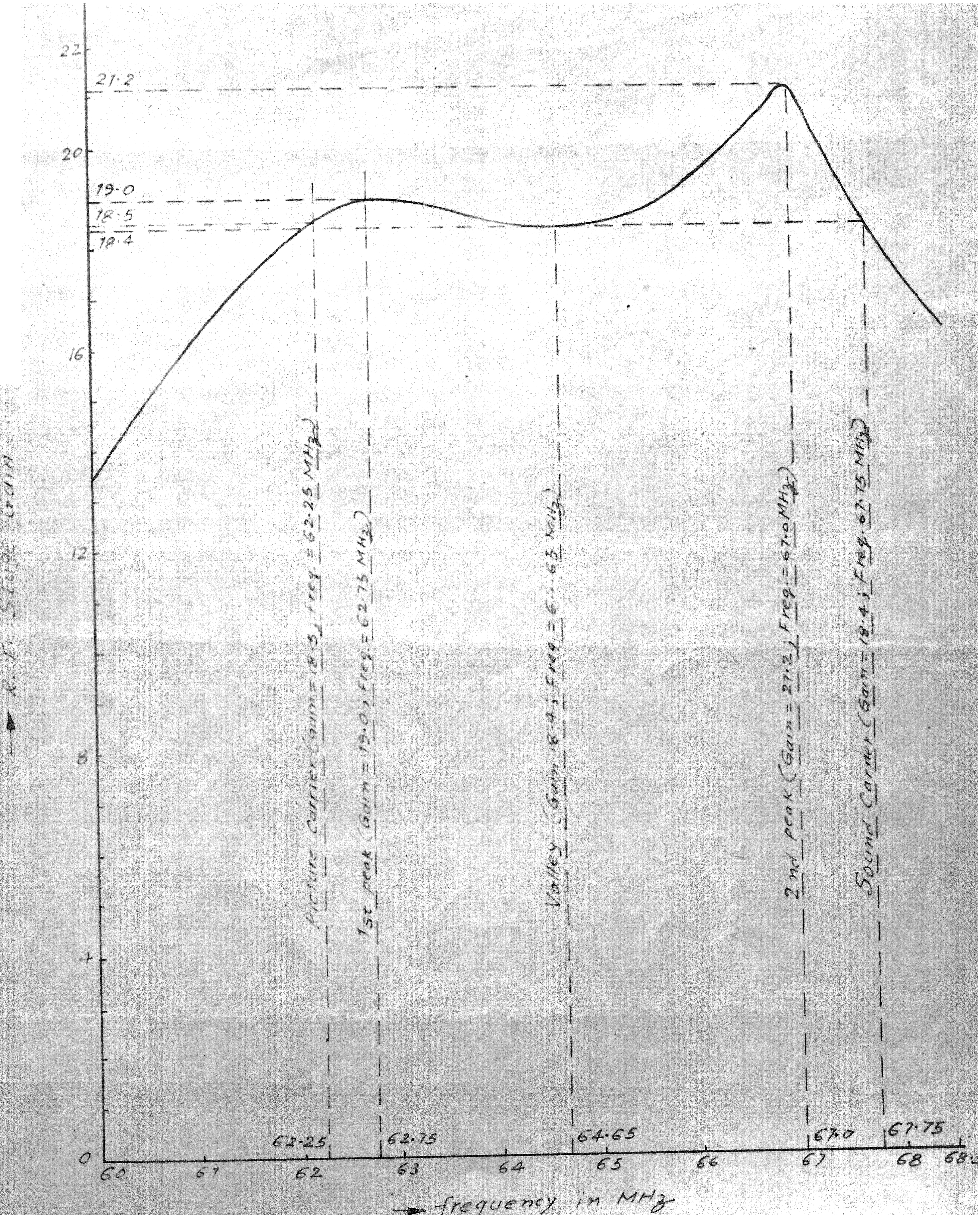


FIG. 2.3 THE PLOT BETWEEN THE R.F. STAGE GAIN AND THE FREQUENCY AT FULL GAIN

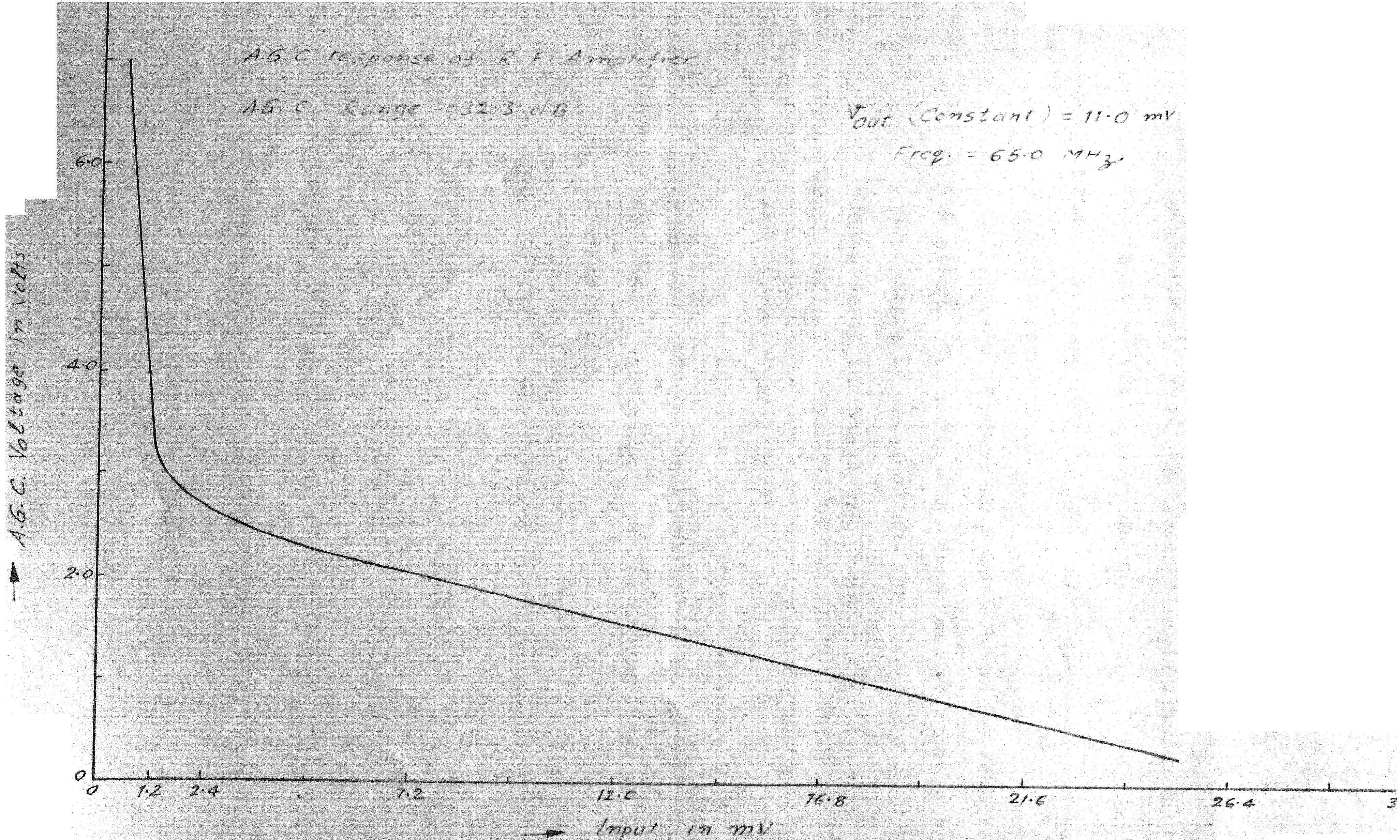


FIG. 2.4 THE PLOT BETWEEN THE A.G.C. VOLTAGE AND THE INPUT R.F. FREQUENCY SIGNAL FOR A CONSTANT R.F. STAGE OUTPUT

grounded partition, because the terminal leads of the local oscillator IC radiate. Finally lay out on the P.C.B should be very carefully drawn.

2.5 Measurements

2.51 R.F.stage:

A gain of about 25.5 dB is obtained from the R.F.stage. The R.F. stage works satisfactorily over a A.G.C. range of about 32 dB. The frequency and A.G.C. responses of the stage are shown in Fig. 2.3 and Fig.2.4 respectively.

2.52 Local oscillator:

By varactor tuning a change of about 5 MHz is possible in the local oscillator frequency. The local oscillator signal voltage at the input of the mixer is about 530 mV.

CHAPTER 3

THE VIDEO I.F. AMPLIFIER AND THE DETECTOR

3.1 The I.F. amplifier circuit design

As already stated an overall gain of 55 dB is required from the V.I.F. amplifier and the frequency response curve should be as in Fig. 1.4. To achieve this, we require a 3-stage amplifier. This is required from the considerations of gain availability and the stability of the amplifier.

Again CA 3028A integrated circuit modules have been used. In addition to providing sufficient drive to the video detector, the last I.F. stage is required to handle, linearly, large signal and noise impulses. Failure to meet this requirement may result in AGC lock-out or improper action of noise immunity circuits. Therefore, for the last stage, the IC 3028A has been used in the differential mode. The first two stages use the IC 3028A, in the cascode mode to attain the maximum gain.

The complete circuit diagram of the video I.F. amplifier and the detector is shown in Fig.3.1.

3.11 First stage

The first stage is a cascode amplifier. In the I.F. band the picture carrier is at 38.9 MHz and the sound

$L_{01} = 0.80\ \mu H$	$R_1 = K\Omega$	$C_{11} = 15\ pF$	$R_{p11} = 750\ \Omega$	$R_{d1} = 56\ \Omega$	$L_{11} = 0.15\ \mu H$
$L_{02} = 0.57\ \mu H$	$R_2 = 2\ K\Omega$	$C_{21} = 12\ pF$	$R_{p21} = 3.3\ K\Omega$	$R_{d2} = 150\ \Omega$	$L_{21} = 1.32\ \mu H$
$L_{03} = 0.65\ \mu H$	$C_B = 1000\ pF$	$C_{22} = 10\ pF$	$R_{p31} = 10\ K\Omega$	$R_{d3} = 100\ \Omega$	$L_{22} = 0.88\ \mu H$
$L_{04} = 0.45\ \mu H$	$C_{c1} = 30\ pF$	$C_{31} = 10\ pF$	$R_{p32} = 33\ K\Omega$	$R_{d4} = 150\ \Omega$	$L_{31} = 1.32\ \mu H$
$R_{T1} = 150\ \Omega$	$C_{c2} = 8.2\ pF$	$C_{32} = 18\ pF$	$C_{m2} = 22\ pF$	$R_{d5} = 150\ \Omega$	$L_{32} = 1.21\ \mu H$
	$C_p = 15\ pF$				

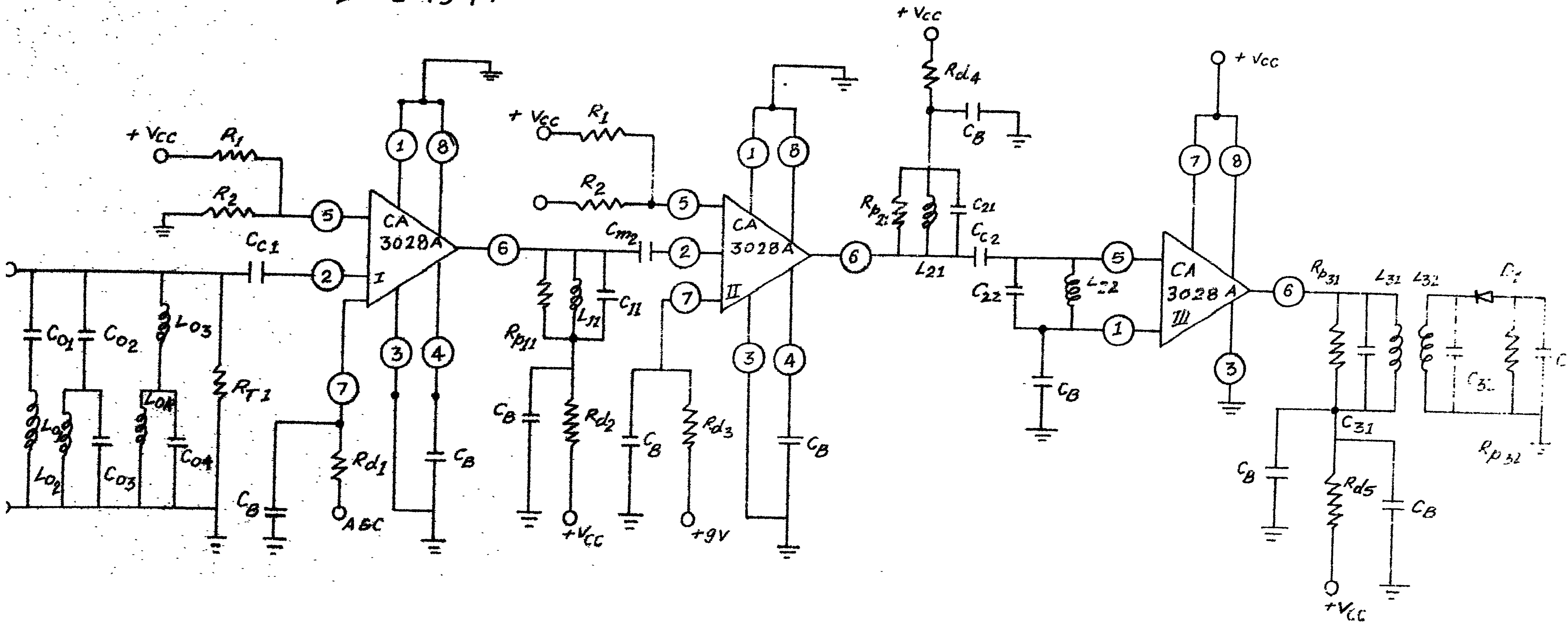


FIG. 3.1. THE THREE STAGE VIDEO I.F. AMPLIFIER AND THE DETECTOR.

carrier is at 33.4 MHz.

At 36 MHz the input admittance of the IC is given as $y_{11} = (3.3 + j4.0)$mmhos.

Thus R_{in} = 300 ohms

and C_{in} = 17.7 pF

A coupling capacitor C_{c1} of value 30 pF is chosen so as to ensure the stability of the amplifier (see section 3.3).

The output admittance of the IC at 36 MHz is given as $y_{22} = (-0.011 + j0.65)$mmhos

This gives R_{out} = -91 Kohms

and C_{out} = 2.88 pF

The bandwidth required from the first stage is of the order of 7 MHz.

Therefore, $Q_L = 36.5/7 = 5.21$

The loaded $Q_L = R_p / wL$. Since the Q_L is small, R_p will have to be small. However, by increasing inductance, a higher R_p could be possible. But higher inductance means less of capacitance to tune at certain frequency. Minimum capacitance is limited by the device itself. At the same time stray capacitances will be very much effective. On this basis we should not use large inductance value.

A load impedance of 0.9 Kohms is selected at the output of first stage.

$$\therefore \quad L = R_p/wQ_L = \frac{900}{2x3.14x36.5x10^6x5.21}$$

$$= 0.754\ \mu H.$$

This requires total capacitance for tuning

$$C_T = 1/w^2L = 25.4\ pF.$$

The load impedance to be put externally R_{p11} will be so as to satisfy the following equation

$$R_{p11} \parallel R_{out} \parallel R_U = 0.9Kohms$$

where $R_{out} = 1/g_{22}$

R_U = unloaded self resistance of the coil

$= Q_U wL = 8.65Kohms \quad (Q_U = 50)$

Thus R_{p11} = 1Kohms

Experimentally R_{p11} = 750ohms gives the desired response.

The input admittance of the 2nd stage is same as that of the first stage, because this is also a cascode stage.

Thus for this stage, R_{in} and C_{in} are given by

R_{in} = 300 ohms and C_{in} = 17.7 pF

Thus the impedance matching requires a capacitance C_{m1}, such that

A load impedance of 0.9 Kohms is selected at the output of first stage.

$$\therefore \quad L = R_p/wQ_L = \frac{900}{2\times 3.14\times 36.5\times 10^6\times 5.21}$$

$$= 0.754\ \mu H.$$

This requires total capacitance for tuning

$$C_T = 1/w^2L = 25.4\ \text{pF}.$$

The load impedance to be put externally R_{p11} will be so as to satisfy the following equation

$$R_{p11} \parallel R_{out} \parallel R_U = 0.9\text{Kohms}$$

where $R_{out} = 1/g_{22}$

R_U = unloaded self resistance of the coil

$= Q_U wL = 8.65\text{Kohms}$ ($Q_U = 50$)

Thus $R_{p11} = 1\text{Kohms}$

Experimentally $R_{p11} = 750\text{ohms}$ gives the desired response.

The input admittance of the 2nd stage is same as that of the first stage, because this is also a cascode stage.

Thus for this stage, R_{in} and C_{in} are given by

$R_{in} = 300$ ohms and $C_{in} = 17.7$ pF

Thus the impedance matching requires a capacitance C_{m1}, such that

$$300 \times \left(\frac{C_{m1} + 17.7}{C_{m1}} \right)^2 = 900$$

or $C_{m1} = 24$ pF.

A 22 pF capacitance is selected as C_{m1}.

Now the total tuning capacitance C_T is

$$C_T = C_{out1} + \frac{C_{in2} \times C_{m1}}{C_{m1} + C_{in2}} + C_{11}$$

where C_{11} is to be put externally

$$\therefore \quad 25.4 = 2.88 + \frac{17.7 \times 22}{22 + 17.7} + C_{11}$$

or $C_{11} = 12.72$ pF

Experimentally, by putting a 15 pF capacitance tuning is obtained.

3.12 Second stage

Now for the 2nd stage, two single tuned, capacitive coupled, circuits are used, so as to obtain the required frequency response.

The first coil is tuned at 35 MHz and the 2nd one at 38 MHz. Both should have a bandwidth of about 4 MHz each.

The overall loads on the tuned circuits R'_{p2} and R''_{p2} are selected as 2.5Kohms and 2Kohms.

Loaded Q for the first tuned circuit $Q_{L21} = 35/4 = 8.75$.

and for the second tuned circuit $Q_{L22} = 38/4 = 9.5$

The required inductances will be

$$L_{21} = \frac{2.5\text{x}10^3}{2\text{x}3.14\text{x}34.5\text{x}10^6\text{x}8.75} = 1.32 \ \mu\text{H.}$$

and $$L_{22} = \frac{2\text{x}10^3}{2\text{x}3.14\text{x}38\text{x}10^6\text{x}9.5} = 0.88 \ \mu\text{H}$$

The total capacitances required for the tuning are

$C_{T21} = 16.3$ pF and $C_{T22} = 20$ pF.

The lower and upper values of coupling capacitances are limited by two different considerations. To make the dip between two peaks , as small as possible, we require loose coupling, and hence a very low value of coupling capacitor. But the maximum signal transfer condition demand a high value of coupling capacitor. A compromise will have to be reached between the two. On this basis the coupling capacitance C_{c2} is selected of value 6.8 pF.

Now the output R/C parallel circuit values of 2nd stage are given as

R_{out} = -91Kohms and C_{out} = 2.88 pF.

The input admittance of 3rd stage (differential mode) is given as $y_{22} = (0.5+j0.8)$ mmhos

This gives R_{in} = 2Kohms and C_{in} = 3.54 pF.

The external capacitances would be

C_{21} = 16.3-2.88-reflected capacitance from the second coil

$$= 16.3-2.88-\frac{6.8\times16}{6.8+16}\text{(approximately)}$$

$$= 9\ \text{pF}.$$

and C_{22} = 20-3.54-reflected capacitance from the first coil

$$= 20-3.54-\frac{6.8\times11}{6.8+11}$$

$$= 12\ \text{pF}$$

Experimentally, the values 12 pF and 10 pF are found to be suitable.

For loading of the first coil

$$R_T = R_{p21} \parallel R_{out} \parallel R_U = 2.5\text{Kohms}$$

$$R_U = 2\times3.14\times35\times10^{6}\times1.32\times10^{-6}\times50 = 14.5\text{Kohms}$$

$$R_{out} = -91\text{Kohms}$$

Therefore, R_{p21} = 3.2Kohms

A value of 3.3Kohms for R_{p21} is selected.

For loading of the second coil

$$R_T = R_{p22} \parallel R_{in} \parallel R_U = 2\text{Kohms}$$

Since R_{in} = 2Kohms and R_U is quite high, there is no need to put any resistance as R_{p22}.

3.13 Third stage

For the third stage a double tuned, inductive-coupled circuit has been used. The primary is tuned at 37 MHz and the secondary is tuned at 35 MHz. Both have the bandwidth of 3.5 MHz each.

$$Q_{Lp} = 37/3.5 = 10.6 \text{ and } Q_{Ls} = 35/3.5=10$$

The corresponding overall load impedances are selected to be 3.25Kohms and 2.75Kohms. The secondary load being the detector impedance in parallel with the self resistance of the coil. Thus the required inductances are

$$L_p = L_{31} = \frac{3.25\text{x}10^3}{2\text{x}3.14\text{x}37\text{x}10^6\text{x}10.6} = 1.32 \ \mu\text{H}$$

$$\text{and} \quad L_s = L_{32} = \frac{2.75\text{x}10^3}{2\text{x}3.14\text{x}35\text{x}10^6\text{x}10} = 1.21 \ \mu\text{H}.$$

The total tuning capacitances required are

$$C_{Ts} = 14.3 \text{ pF} \quad \text{and } C_{Tp} = 17.5 \text{ pF}$$

Now, $C_{Ts} = C_{31} + C_{out}$

where C_{31} = External capacitance

C_{out} = Output capacitance of the third stage given as 2.2 pF.

$\therefore \quad C_{31} = 14.3-2.2=12.1$ pF

and $\quad C_{32} = C_{Tp} = 17.5$ pF.

The capacitances put in the circuit are 10 pF and 18 pF.

For primary loading

$$R_{Tp} = R_{p31} \parallel R_{out} \parallel R_U = 3.25\text{Kohms}$$

$$R_U = 2\text{x}3.14\text{x}37\text{x}10^{6}\text{x}1.[illegible]\text{x}10^{-6}\text{x}\ 50 = 15.8\ \text{Kohms}$$

$$\therefore\ R_{p31} = 9.2\text{Kohms}$$

A 10 Kohms resistance is used as R_{p31}

For secondary loading

$$R_{Ts} = R_{p32} \parallel R_U = 2.75\ \text{Kohms}$$

$$R_U = 2\text{x}3.14\text{x}35\text{x}10^{6}\text{x}1.21\text{x}10^{-6}\text{x}50 = 13.3\ \text{Kohms}$$

$$\therefore\ R_{p32} = 3.43\ \text{Kohms}$$

The detector load of 3.3 Kohms is put as R_{p32}.

3.14 Biasing and other considerations

The biasing resistors R_1 is 1Kohms and R_2 is 2Kohms so that the terminal 5 is biased at 6 volts. All bypass capacitors are of value 1500 pF.

The decoupling resistor R_{d1} for the AGC supply is 56 ohms and the decoupling capacitor is 1500 pF. For the terminal 7 of the 2nd stage, the decoupling resistor has a value of 100 ohms and the decoupling capacitor has a

value of 1500 pF. The other decoupling resistances are of value 150 ohms and the decoupling capacitances are of value 1500 pF.

3.2 The I.F. traps

We have to put I.F. traps at three frequencies, namely, the picture carrier of the higher adjacent channel, the sound carrier of the lower adjacent channel, and at the sound carrier, to stop the intermixing of video and sound signals.

The picture carrier and the sound carrier of the higher and lower adjacent channel respectively are to be suppressed minimum by 40 dB. The sound carrier of the signal is to be attenuated by 25 dB. The 150 ohms resistance*

3.21 Trap at picture carrier of higher adjacent channel

The picture carrier of the higher adjacent channel will be at 69.25 MHz and in the I.F. band it will be at 31.9 MHz.

A series L-C circuit is connected in parallel with the input, tuned at 31.9 MHz. The effective circuit would be as shown in Fig. 3.2. The other two trap circuits will not have any effect at this frequency, this is ensured by using high Q circuits.

At 31.9 MHz frequency, the input admittance of the first stage is given by $y_{11} = (3+j4)$ mmhos.

* in parallel to the trap circuits is put to achieve the required attenuation.

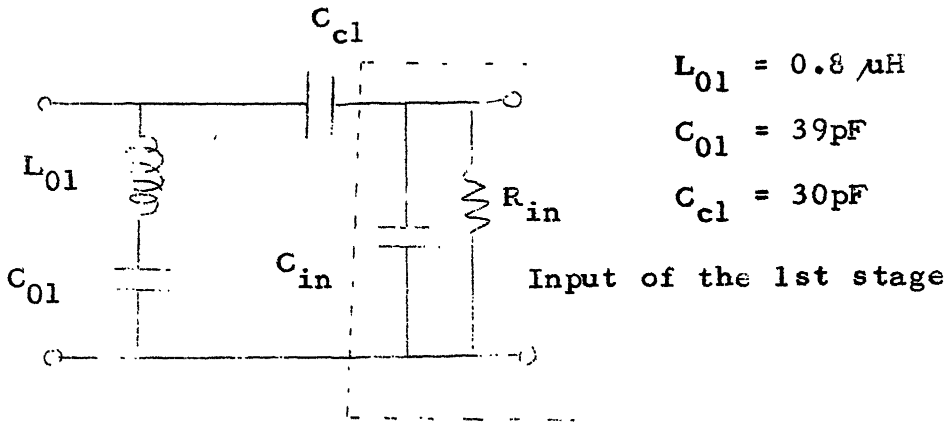


Fig. 3.2 31.9 MHz trap circuit

This gives R_{in} = 333 ohms and C_{in} = 20 pF

L_{01} is selected to be 0.8 μH with an unloaded Q of 60. The C_{01} can be calculated from the condition of resonance at 31.9 MHz and turns out to be 43.5 pF. A 39 pF capacitance has been used as C_{01}.

3.22 Trap at sound carrier of lower adjacent channel

The sound carrier of the lower adjacent channel at 60.75 MHz appears in the I.F. band at 40.4 MHz.

A trap circuit of two inductances and one capacitance is connected. The effective circuit is shown in Fig.3.3

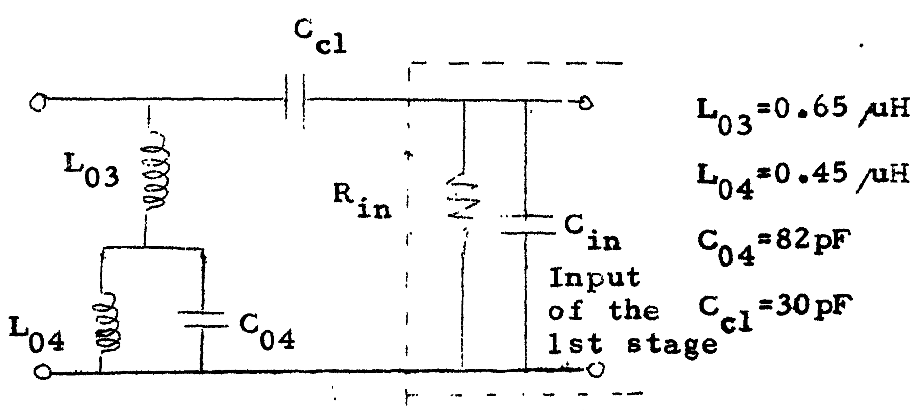


Fig.3.3 40.4 MHz trap circuit

At 40.4 MHz the input admittance y_{11} is given by

y_{11} = (0.35+j4.05) mmhos

This gives R_{in} = 286 ohms and C_{in} = 15.3 pF

L_{03} and L_{04} are chosen to be 0.65 μH and 0.45 μH respectively with unloaded Q's of 60.

For resonance condition C_{04} comes out to be 87 pF. A value of 82 pF is chosen.

3.23 Trap at sound carrier

The sound carrier which is at 33.4 MHz, is to be attenuated by about 20 dB with respect to to the vision carrier.

A trap circuit with two capacitors and one inductor is chosen.

The input admittance y_{11} is given by y_{11}

y_{11} = (0.32+j4.0) mmhos

This gives R_{in} = 312 ohms and C_{in} = 19 pF.

The effective circuit is shown in Fig. 3.4

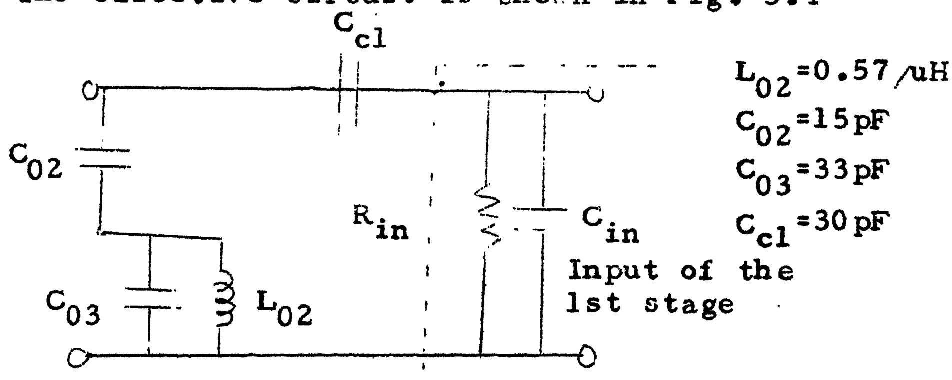


Fig. 3.4 33.4 MHz trap circuit

The value of capacitors are chosen to be 15 pF and 33 pF. For resonance, the inductance required is 0.57 μH, assuming an unloaded Q of 60.

3.3 A.C. stability

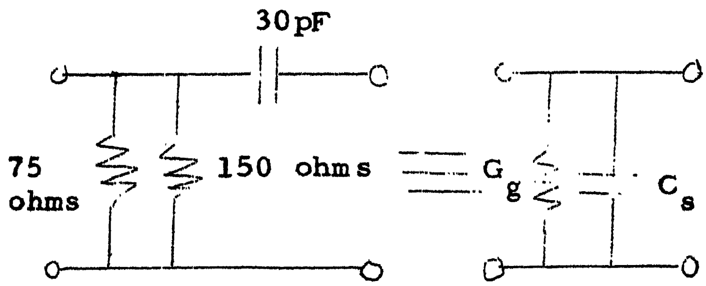
3.31 Stability for first stage

At 36 MHz the admittance parameters of CA 3028A are given as

$$y_{11} = (3.3+j4.0) \text{ mmhos and } y_{12} = (4.0-j2.5)\ \mu\text{mhos}$$

$$y_{21} = (85-j53)\text{mmhos and } y_{22} = (-0.011+j0.65)\text{mmhos}$$

The traps at the center frequency will be in effective. Thus the source impedance circuit is



Now, $z = 1/jwC + R = (1+jwRC)/jwC$

or $y = G_g + jwC_g = (w^2RC^2 + jwC)/(1+w^2R^2C^2)$

$\therefore$ $G_g = w^2RC^2/\ (1+w^2R^2C^2)$

$R = 50$ ohms; $C = 30$ pF and $w = 2x3.14x36x10^6$ Hz

$\therefore$ $G_g = 2.04$ mmhos

and $G_L = 1.11$ mmhos

$g_{11} = 3.3$ mmhos; $g_{22} = -0.0125$ mmhos

$L = 465\times10^{-9}\mu$ mhos^2; $M = 187.5\times10^{-9}\mu$ mhos^2

Applying Stern's stability criterion

$$\therefore \quad k = \frac{2(g_{11}+G_g)\ (g_{22}+G_L)}{(L+M)} = 18$$

Thus, this stage is very stable

3.32 Stability for the second stage

For the second stage which is ~~alos~~ also a cascode stage, all devices parameters are given same as that of the first stage.

$G_g = g_{11}$ (matched)

$g_{22} + G_L = 0.4$ mmhos (since the total load is 2.5Kohms)

Thus, $$k = \frac{2(g_{11}+G_g)(g_{22}+G_L)}{L+M} = 7.4$$

This stage is also stable

3.33 Stability for the third stage

For this stage (differential mode) the parameters are given by at f = 36 MHz

$g_{11} = 0.5$mmhos; $g_{22} = 0.13$ mmhos

$y_{12} = (0.05-j0.01)$mmhos and $y_{21} = (-14+j3)$mmhos

$M = -0.67\times10^{-6}\mu$ mhos^2; $L = 0.73\times10^{-6}\mu$ mhos^2

$G_g + g_{11} = 0.5$ mmhos

$g_{22} + G_2 = 0.308$ mmhos

$$\therefore \quad k = \frac{2(g_{11}+G_g)(g_{22}+G_L)}{L + M}$$

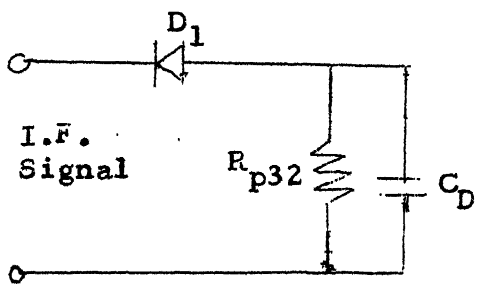
$$= \frac{2 \times 0.5 \times 0.308}{0.06}$$

$$= 5.14$$

Therefore, this stage is also stable.

3.4 The detector design

For detection of I.F. frequencies diode 0A 90 is selected. The detector circuit is shown in Fig. 3.6.



D_1 : 0A 90

R_{p32} = 3.3Kohms

C_D = 33 pF.

Fig. 3.6 The video detector circuit

The time constant RC should be such that the cut-off frequency 1/RC lies sufficiently above the vision band. The 1/RC frequency should also lie much below the I.F. band.

For C_D = 33 pF.

$RC = 3.3 \times 10^{3} \times 33 \times 10^{-12}$

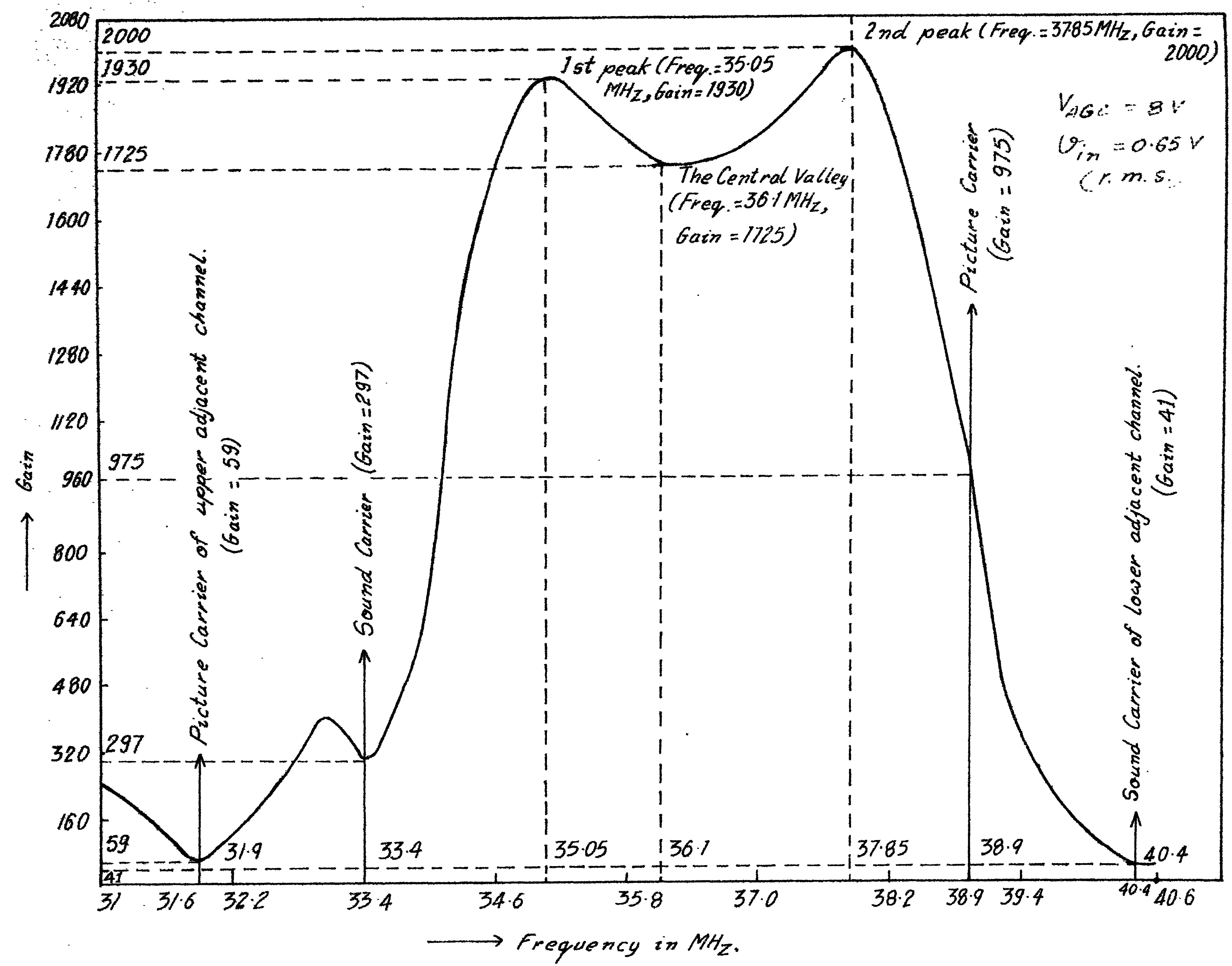


FIG.3·7. PLOT BETWEEN THE V.I.F. STAGE GAIN AND THE I.F. BAND FREQUENCIES

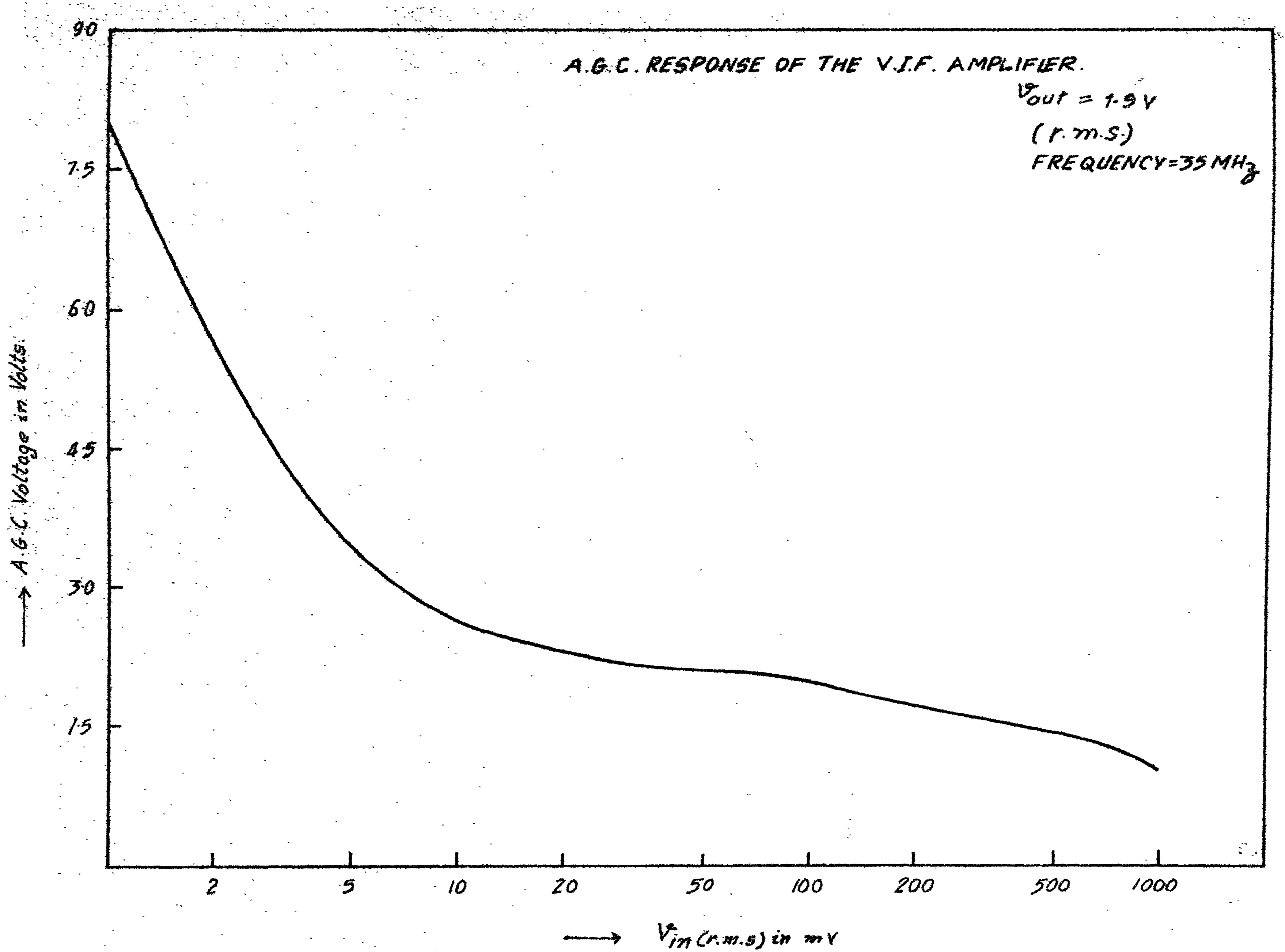


FIG. 3.8. PLOT BETWEEN THE A.G.C. VOLTAGE AND THE INPUT SIGNAL OF THE V.I.F. AMPLIFIER FOR A CONSTANT OUTPUT.

or RC $= 10.90 \times 10^{-8}$

or $1/RC = 9.18$ MHz.

This is sufficiently above the vision band for monochrome reception.

3.5 Measurements

3.51 Frequency response

The frequency response of the V.I.F. amplifier is shown in Fig. 3.7. The frequency response is satisfactory. The gain of the amplifier is more than the required value of 55 dB.

3.52 A.G.C. response

The A.G.C. response of the I.F. amplifier is shown in Fig. 3.8. Only a 50 dB A.G.C. range was required but the amplifier works satisfactorily for a 60 dB range.

3.53 Detector efficiency

The detector efficiency is 55%. It was designed for a 60% efficiency.

CHAPTER 4

THE SOUND CIRCUITS

4.1 The S.I.F. amplifier and the discriminator

Integrated circuit module TAA 570[9] has been used for the sound circuits. This I.C. includes both S.I.F. amplifier and the discriminator. The TAA 570 is a four stage limiter-amplifier with f.m. detector and remote control stage. In this circuit excellent a.m. suppression is obtained by the use of a differential amplifier with a constant current source. The f.m. detector is a symmetrical phase detector. The remote control stage has a control range of about 80 dB on the a.f. output signal.

Typical data for this I.C. is as follows:-

Supply voltage	V_p	typ.	12 V
Frequency	f_o		5.5 MHz
Total current drain	I_{tot}	typ.	19 mA
Input limiting voltage	V_{ilim}	typ.	100 μV
A.M. rejection at V_i=10 mV		typ.	47 dB
Output at 50KHz frequency deviation	V_o(rms)	typ.	1.8V
Distortion at a frequency deviation of 50KHz and full gain	d	typ.	2.5%

Ratings and some other important characteristics are given in Appendix II.

The circuit recommended with this I.C. is shown in Fig. 4.1.

The input band pass filter is connected to the video detector via a small capacitor of 3.3 pF. The input bandpass filter has the following characteristics

L_1 = 18 μH; G_{L1} = 56 μmhos; Q_{L1} = 24 and C=47 pF

L_2 = 2.2 μH; G_{L2} = 490 μmhos; Q_{L2} = 23 and C=390 pF.

The transfer ratio $V_1/V_2 = 0.54$

The detector coil L_3 =8.3 μH; C=100 pF has a loaded Q of 25.

It should give a typical output voltage, at this Q and full gain, of 550 mV for Δf = 15 KHz with output signal distortion of 1%.

In the circuit of TAA 570[9], it is noted that the terminal no.3 and 4 are the collector and base respectively of the output transistor (TR30).

Therefore, instead of applying the volume control at terminal no. 4 , it could also be applied to terminal no. 3 itself and thus saving of components is achieved.

Therefore, the circuit used is shown in Fig. 4.2.

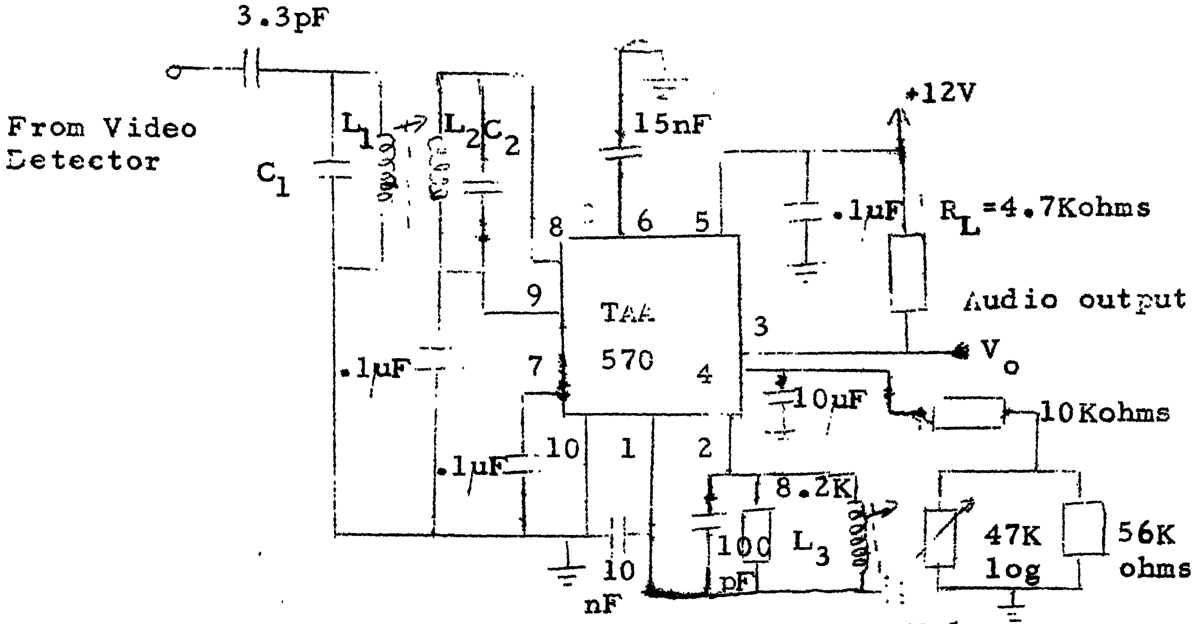


Fig. 4.1 The recommended circuit for TAA 570

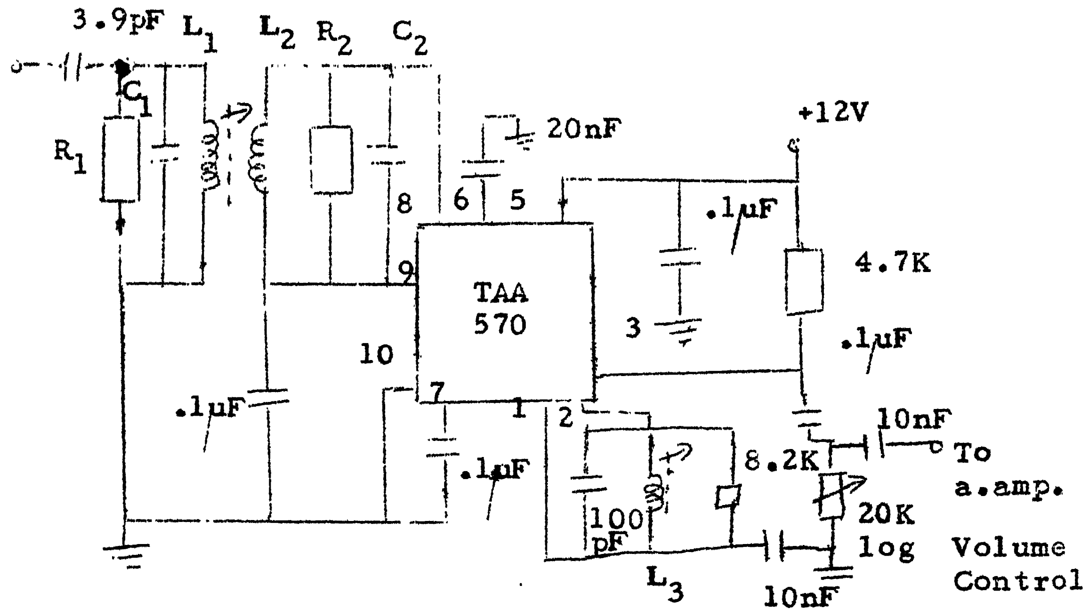


Fig. 4.2 The circuit used for TAA 570

4.2 Audio amplifier

The requirements of the audio amplifier are the following:-

1. The input impedance of the audio amplifier should be of order of 40Kohms. This figure is chosen so that it may not load the previous stage (discriminator), which has an output impedance of little less than 4Kohms.

2. Minimum signal strength at the input of the audio amplifier should be 50 nW for an output power of 1W.

3. The impedance of the loudspeaker is 5 ohms.

To meet the above requirements a complementary-symmetry (pnp-npn) class B power amplifier stage is used. A cascode amplifier is needed to attain the required level of voltage and the current at the input of the power amplifier. The complete circuit diagram of the audio amplifier is shown in Fig. 4.3. For the power amplifier the transistors AC 187, AC 188 are used and for the cascode amplifier, the transistors used are BC 108 and AC 132.[8]

The d.c. biasing operating points of the transistors are

$V_{CE1} = 3.5V \qquad I_{C1} = 300\ \mu A$

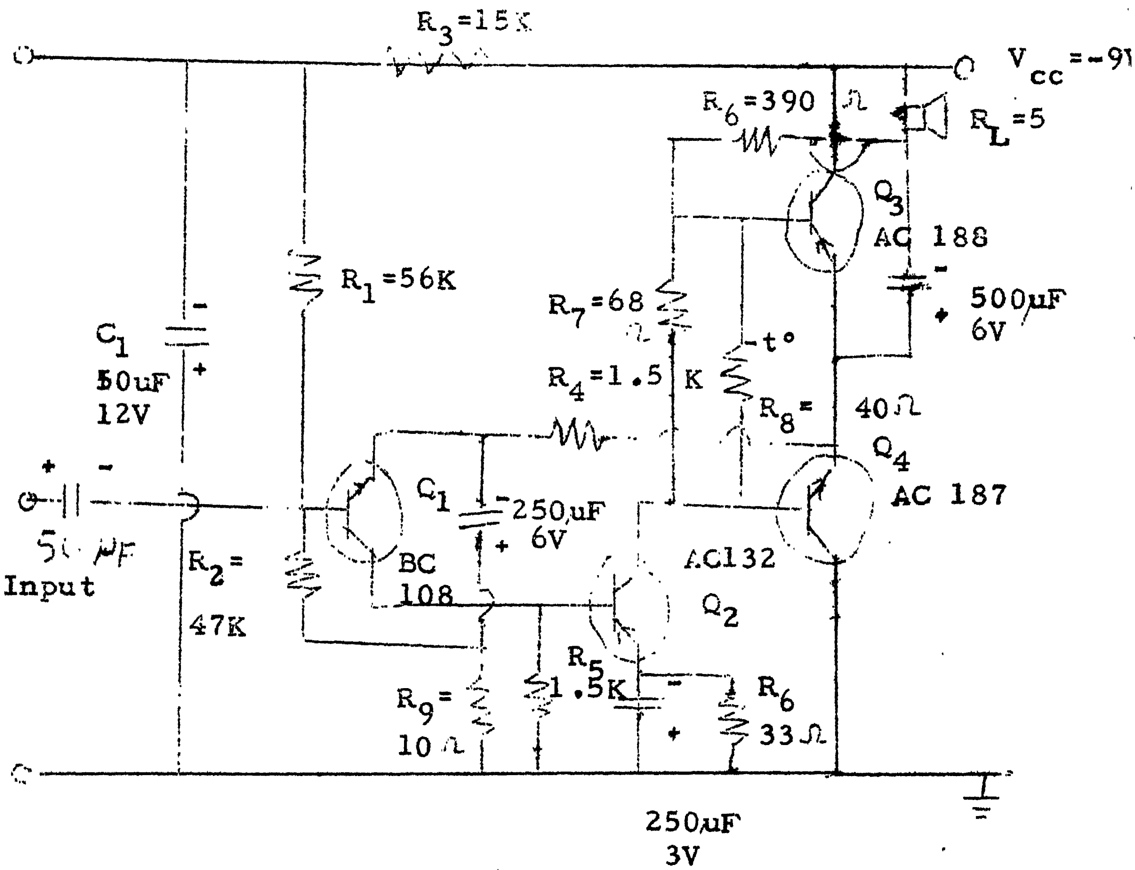


Fig. 4.3 The audio amplifier

$V_{CE2} = -4V \qquad I_{C2} = -10\ mA$

$|V_{CE3}| = |V_{CE4}| = 4.5V\ ; |I_{C3}| = |I_{C4}| = 5\ mA$

The base Q_1 is biased at approximately -3.6V.

$V_{B1} = R_2 x V_{cc} / (R_1 + R_3) = -3.6V$

The base voltage of Q_2 is

$V_{B2} = I_{C2} \times R_6 + V_{BE2} = -0.53V \ (V_{BE2} = -0.2V)$

The collector currents of Q_3 and Q_4 are controlled by R_7. The current I_{C2} is governed by

the resistance R_6. The I_{C1} is controlled by R_5. R_4 is used for proper V_{CE1}.

The thermister R_8 is used so as to stabilize the base to base voltage of Q_3 and Q_4 with the increase in the signal strength. As the signal level increases, the base current increases and in order to stabilize the base to base voltage of Q_3 and Q_4, the resistance of the parallel combination of R_7 and R_8 should decrease. This is achieved by a negative temperature coefficient resistance (thermistor)R_8.

4.3 Measurements

4.31 S.I.F. amplifier and the discriminator

The voltage at the output of the discriminator is 0.85 V(r.m.s.), for a frequency deviation of 50KHz and a modulation frequency of 1KHz. The output voltage remains constant till the input is reduced to a value of 1 mV(r.m.s.). The input-output characteristics for the S.I.F. amplifier and the discriminator is shown in Fig.4.4.

The output voltage follows linearly the frequency deviation up to a value of 20KHz. The response is shown in Fig. 4.5.

The amplitude modulated signals are suppressed by 40 dB.

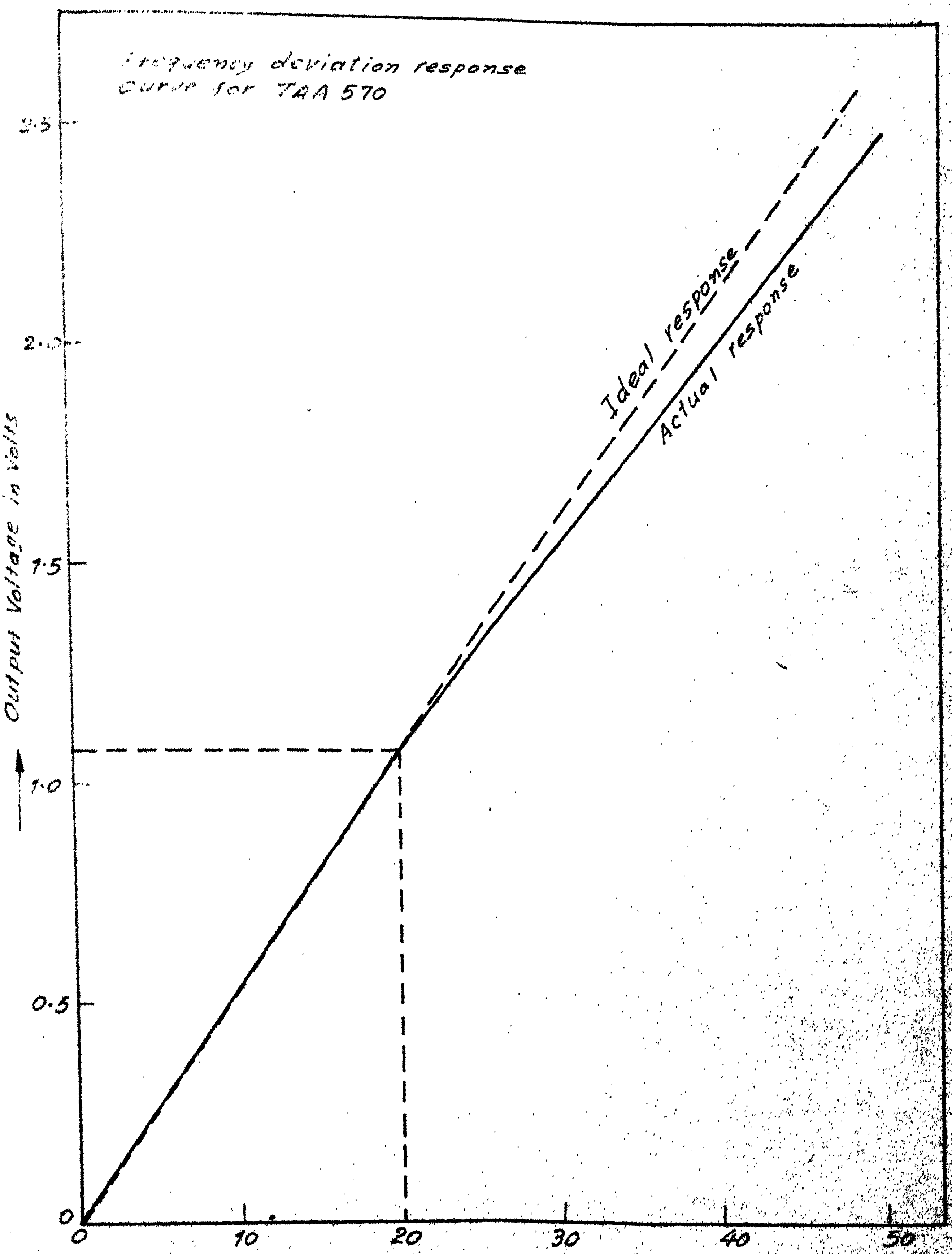


FIG. 4.5 PLOT BETWEEN OUTPUT VOLTAGE AND FREQUENCY DEVIATION OF TAA 570

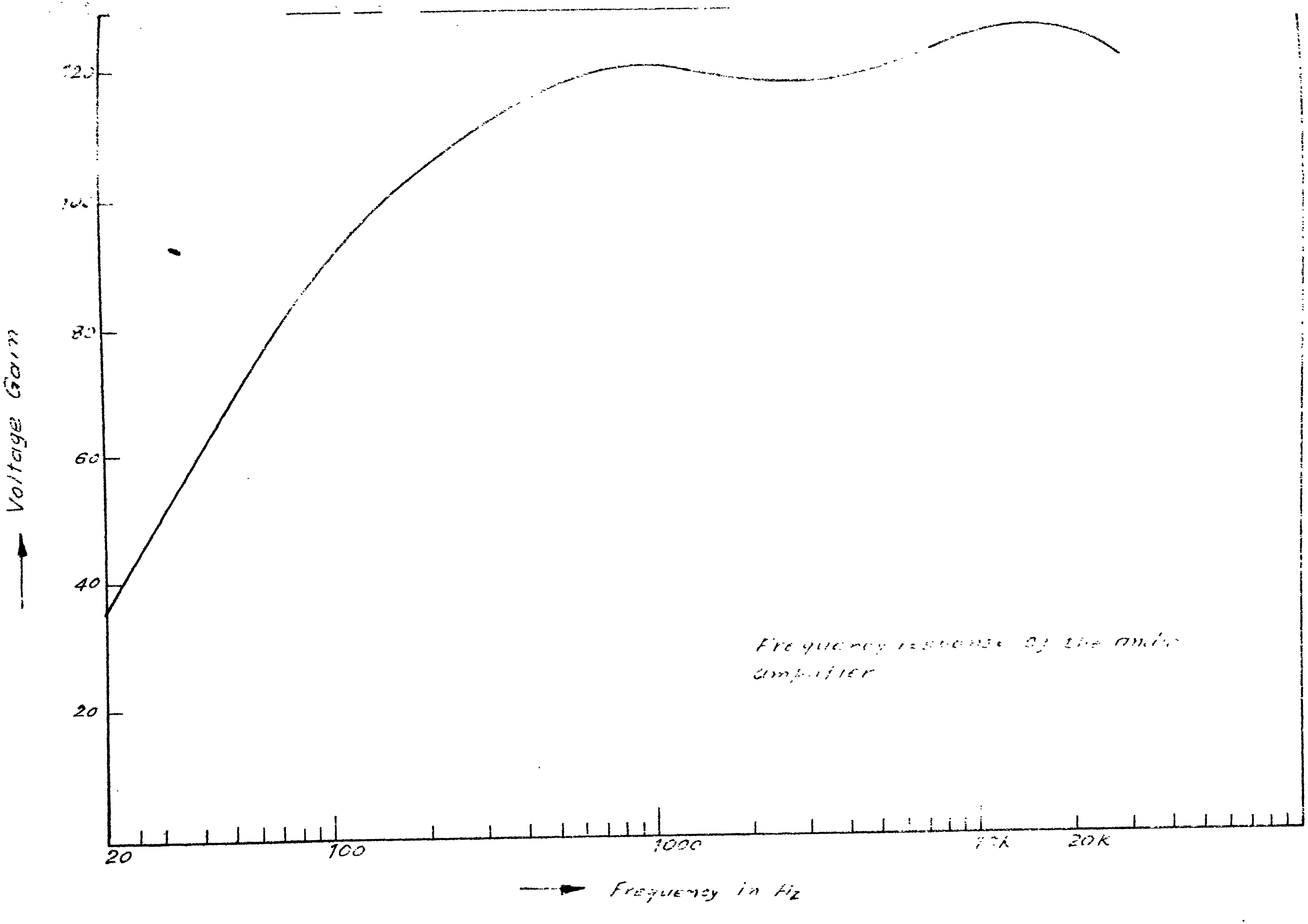


FIG. 4·6 THE PLOT BETWEEN THE VOLTAGE GAIN AND THE FREQUENCY OF THE AMPLIFIER

4.32 Audio amplifier

The audio amplifier gives an output of 1 watt for an input of about 23 mV(r.m.s.). The frequency response of the audio amplifier is shown in Fig. 4.6.

CHAPTER 5

A.G.C.CIRCUITS

The I.C. module TAA 700 is used for A.G.C. circuits. The TAA 700 is a silicon monolithic integrated signal processing circuit, specially produced for the television receiver. It combines following functions:

1. Video pre-amplifier with emitter follower output.
2. Gated A.G.C. detector supplying the A.G.C. voltages for the vision I.F. amplifier and tuner (delayed).
3. Noise inverter for gating the A.G.C. and sync. separator circuits.
4. Sync. separator.
5. Automatic horizontal synchronisation.
6. Vertical sync. pulse separator.
7. Blanking facility for the video amplifier.

The circuit can handle signals with negative modulation only.

Some of the typical data of the I.C. are as follows:-

1.	Supply voltage	V_p	typ.	12 V.
2.	Ambient temperature	Tamb		25°C
3.	Video input voltage (peak to peak value)	$V_{10-16\,(p-p)}$		2 V

4.	Voltage gain of the video amplifier	G_v	typ.	9.5 dB
5.	A.G.C.voltage for I.F.part (R_1= 2 Kohms)	V_{4-16}	typ.	0 to 8V
6.	A.G.C. voltage for tuner (R_1=1Kohms)	V_{6-16}	typ.	0 to 7 V
7.	Output voltage horizontal phase detector	$\pm V_{2-1}$	typ.	3 V
8.	Vertical sync. output voltage (positive going pulse;peak to peak value)	$V_{15-16(p-p)}$		10 V

Ratings

Supply voltage	V_p	max.	16 V.
Power dissipation	P_{lot}	max.	600 mW
Storage temperature	T_{stg}		-25 to+125°C
Operating ambient temperature	Tamb		-25to+125°C

For the details of characteristics see Appendix III. The operating circuit for TAA 700 is shown in Fig. 5.1.

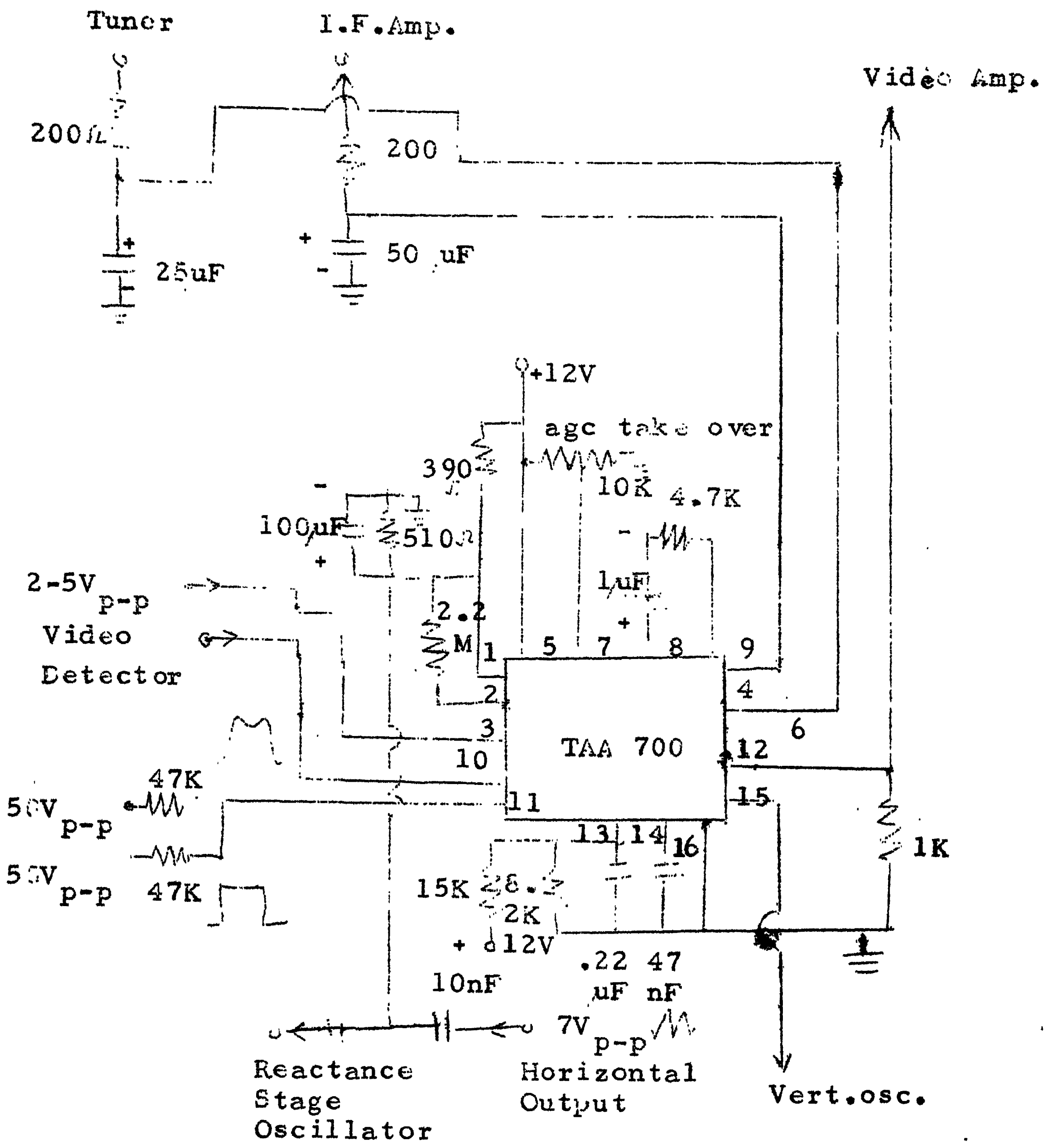


Fig. 5.1 The circuit for TAA 700

CHAPTER 6

CONCLUSIONS

Study, design and fabrication of the following stages of the T.V. receiver have been completed:

1. The tuner
2. The video I.F. amplifier with the detector
3. The sound I.F. amplifier with the discriminator
4. The audio amplifier
5. The A.G.C. circuits

The performance measurements of the above stages have also been given. The tuner performance has not been up to the mark as it has been found that the local oscillator signal interferes with the R.F. signal at the input of the mixer. A better layout and shielding between the R.F. stage and the mixer could improve the performance of the tuner. Some more work has to be done in this direction. The A.G.C. circuits could not be tested because of the want of the blanking and the keying pulses from the line output stage.

The stages have been tested individually. The integration of the stages could not be done because of the shortage of the time.

APPENDIX I

SOME OF THE RATINGS OF THE I.C.

CA 3028 A

CA 3028A

DIFFERENTIAL/CASCODE AMPLIFIERS for communications and industrial equipment at frequencies from dc to 120 MHz.

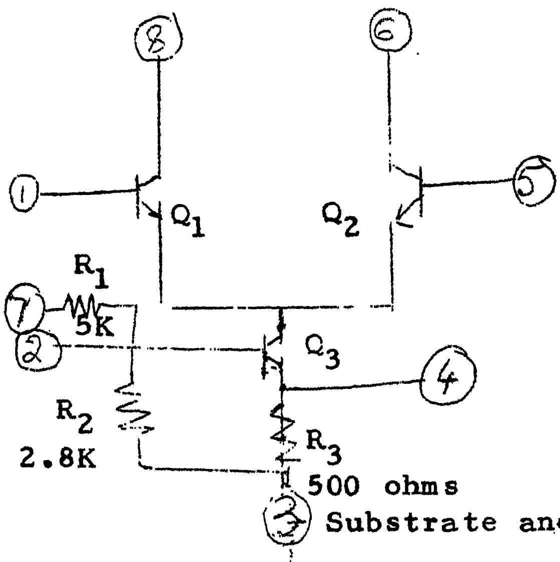
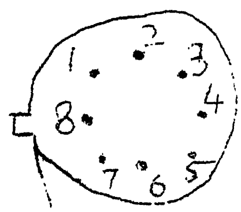


Fig. 11: Schematic Diagram for CA3028A



Bottom View

Fig. 12: Base Diagram for CA3028A.

Maximum Voltage Ratings

Terminal No.	1	2	3	4	5	6	7	8
1		0 to -15	0 to -15	0 to -15	+5 to -5	*	*	+20 to 0
2			+5 to -11	+5 to -1	+15 to 0	*	+15 to 0	*
3				+10 to 0	+15 to 0	+30 to 0	+15 to 0	+30 to 0
4					+15 to 0	*	*	*
5						+20 to 0	*	*
6							*	*
7								*
8								

Fig. 13: Maximum Voltage Ratings for CA3028A.

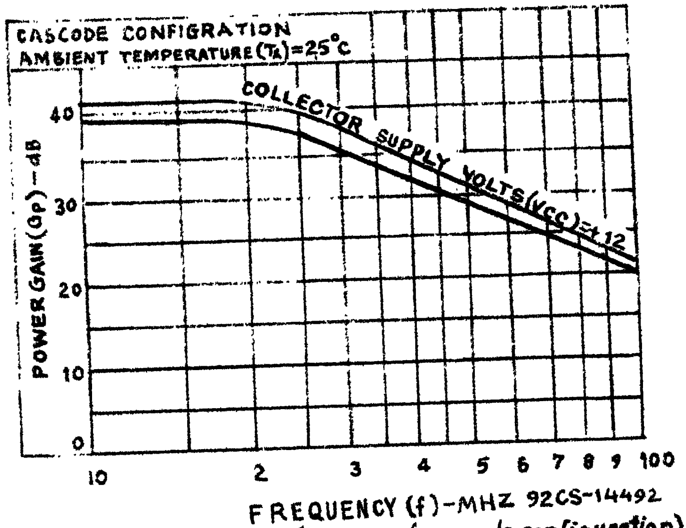


Fig. 1. - Powergain Vs. frequency (cascode configuration) for CA3028A

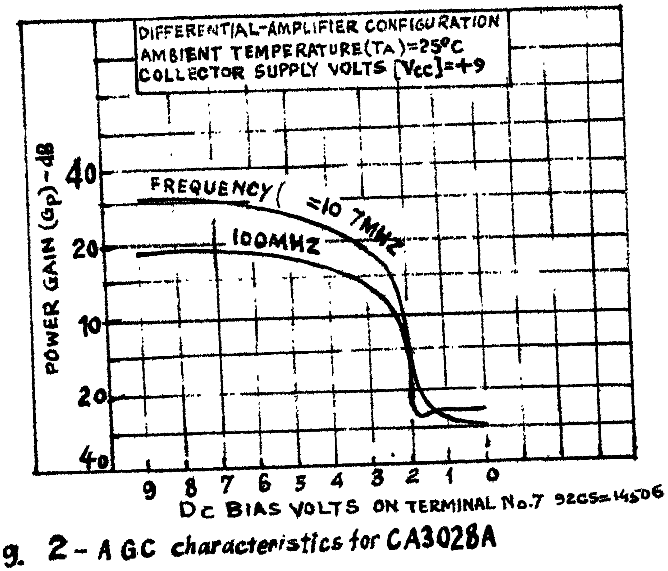


Fig. 2 - A GC characteristics for CA3028A

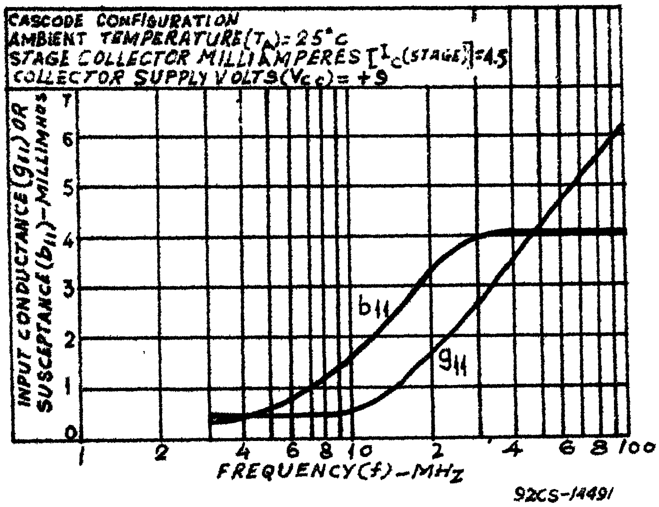


Fig. 3. Input admittance (Y_{11}) vs. frequency (cascode configuration) for CA3028A.

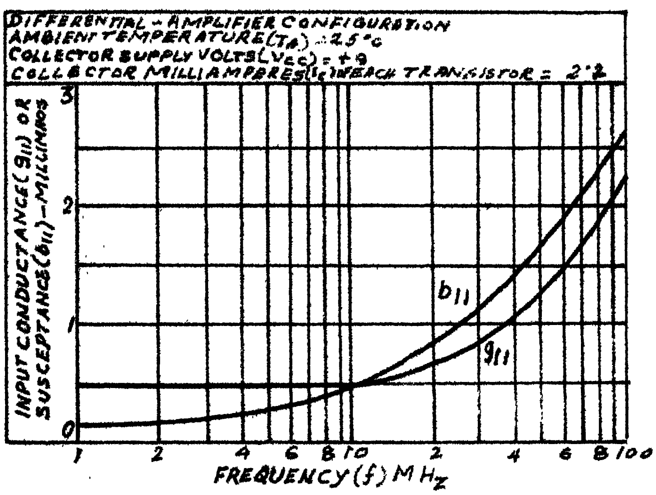


Fig. 4 – Input admittance (Y_{11}) vs. frequency (differential-amplifier configuration) for CA3028A.

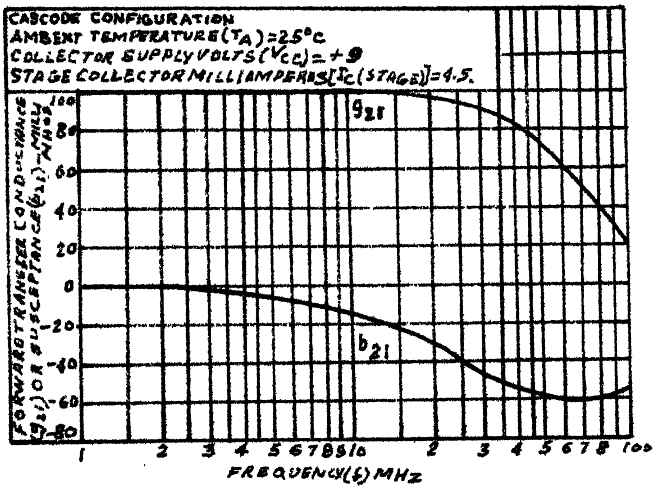


Fig. 7 Forward transadmittance (Y_{21}) vs. frequency (cascode configuration) for CA3028A.

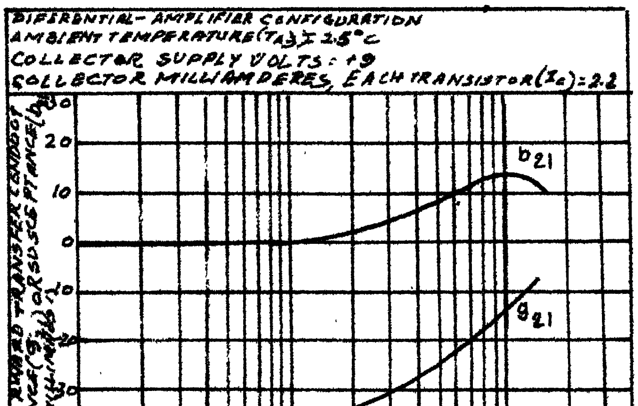


Fig. 8. Forward transadmittance (Y_{21}) vs. frequency (differential-amplifier configuration) for CA3028A.

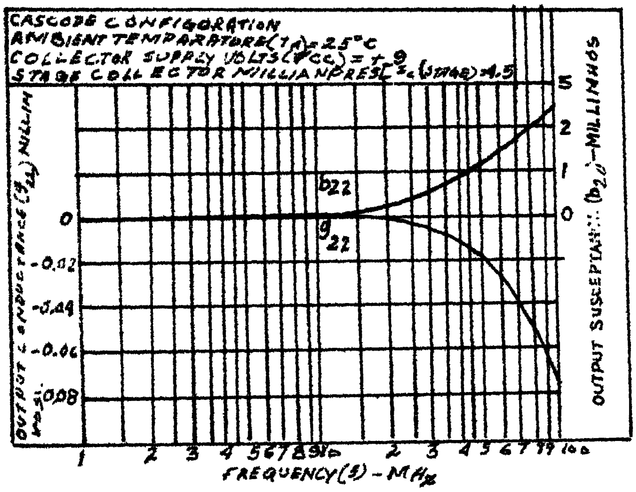


Fig. 9. Output admittance (Y_{22}) vs. frequency (cascode configuration) for CA3028A.

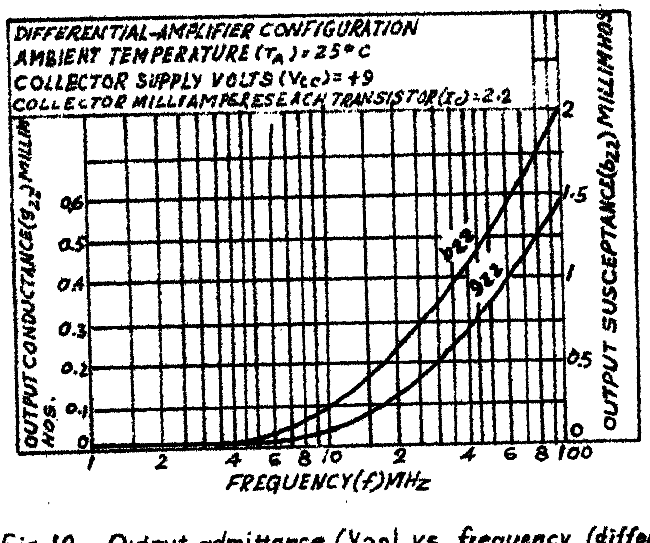


Fig.10. Output admittance (Y_{22}) vs. frequency (differential-amplifier configuration) for CA3028A.

Maximum Ratings at 25°C

Dissipation

at T_A = 25°C----------------------450

at T_A = 25°C to T_A = 85°C --------450

above T_A=85°C derate linearly---- 5

The **chart given above** gives the range voltages which can be applied to the terminals horizontally with respect to the terminals list vertically. For example the voltage range to t horizontal terminal 4 with respect to terminal -1 to + 5 volts

Maximum Current Ratings

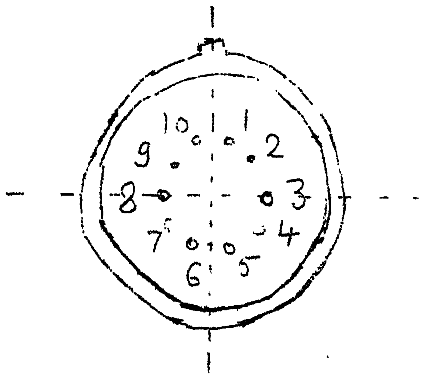
Terminal No.	I_{in} mA	I_{out} mA
1	0.6	0.1
2	4	0.1
3	0.1	23
4	20	0.1
5	0.6	0.1
6	20	0.1
7	4	0.1
8	20	0.1

Typical dynamic characteristics of CA3028A are Fig. 1-Fig.10

APPENDIX II

SOME OF THE RATINGS OF THE I.C.

TAA 570



Bottom View

Fig.1 Base Diagram for TAA 570

Ratings: Limiting values

Voltages:

Pin No.1	Voltage		(Do not apply an external voltage source)
Pin No.2	Voltage		(Do not apply an external voltage source)
Pin No.3	Voltage	V_{3-10}	0 to + 18 V
Pin No.4	Voltage; $I_4 < 1mA$	V_{4-10}	0 to +6V
Pin No.5	Voltage	V_{5-10}	0 to +18V
Pin No.6	Voltage		(Do not apply an external voltage source)

Pin No.7	Voltage;	$I_7 < 1mA$	V_{7-10}	0 to + 6 V
Pin No.8	Voltage:	$I_8 < 1mA$	V_{8-10}	0 to + 6 V
Pin No.9	Voltage		V_{9-10}	0 to + 6V

Temperatures

Storage temperature	T_{stg}	-25 to+125°C
Operating ambient temperature	T_{amb}	-25 to+125°C

Total power dissipation

At 25°C

P_{tot} (for dc) = 0.35 watts

P_{tot} (for time period < 60S) = 0.50 watts

Input limiting voltage

f_o = 5.5 MHz; Δf = 15 KHz; f_m=1KHz V_{ilim} (typ.)=100 μV.

The graph between output and input voltages is shown in Fig.2.

A.M. suppression

F.M.: f_o = 5.5 MHz; ΔF =15 KHz; f_m =1 KHz

A.M.: f_o = 5.5 MHz; m=0.3; f_m=1KHz

Fig. 3 shows the graph between α (AM suppression) and input voltage.

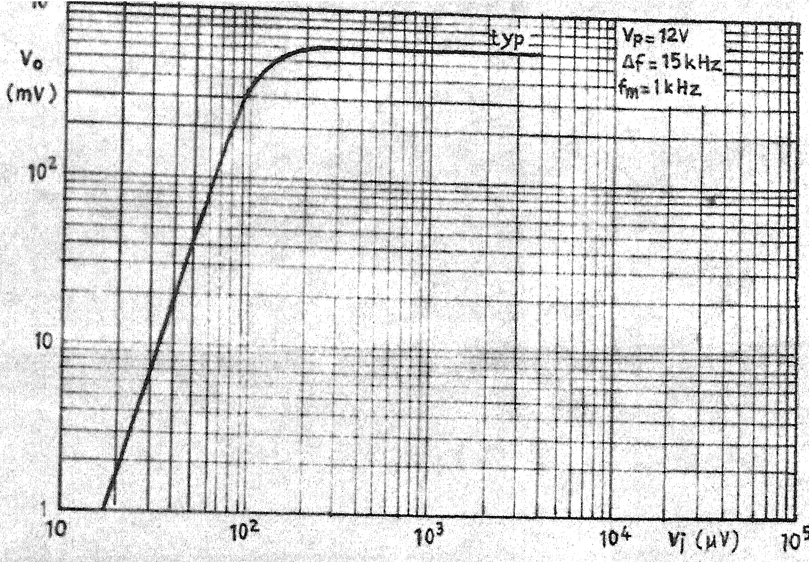


Fig. 2 : OUTPUT VOLTAGE V_s INPUT VOLTAGE FOR TAA 570

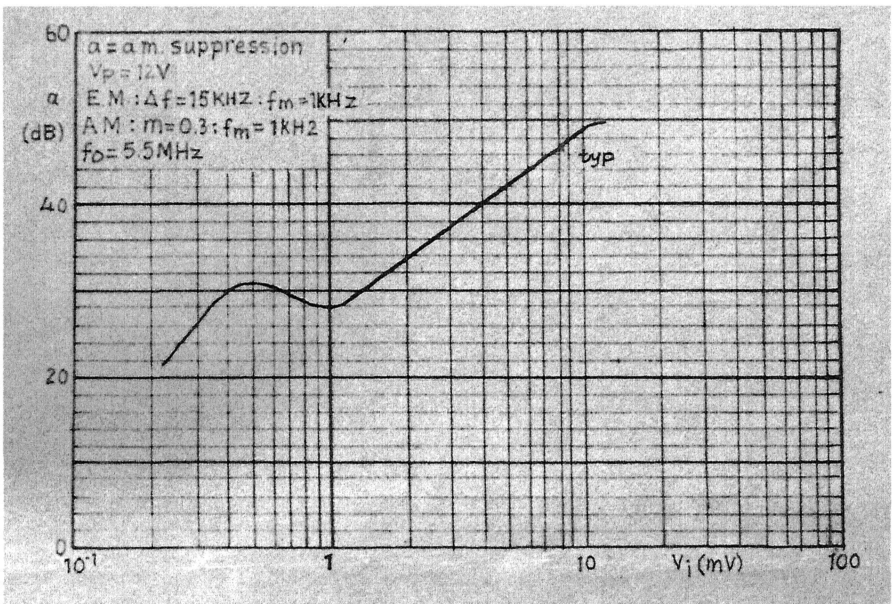


Fig. 3 . A.M.SUPPRESSION (α) VS INPUT VOLTAGE FOR TAA 570

Distortion

At full gain and Δf = 15KHz d(typ) 1%

Δf = 50KHz d(typ.)2.5%

measuring conditions f_o=5.5 MHz, f_m=1KHz.

Y Parameters

Input admittance at f_o =5.5 MHz

y_i (typ.)= (230+j450) μ mhos

Output admittance at f_o=5.5 MHz

y_o(typ.) = (120+j330) μmhos

Feedback admittance at f_o=5.5 MHz

y_r(typ.) = $|65|$ $e^{j150°}$ n mhos

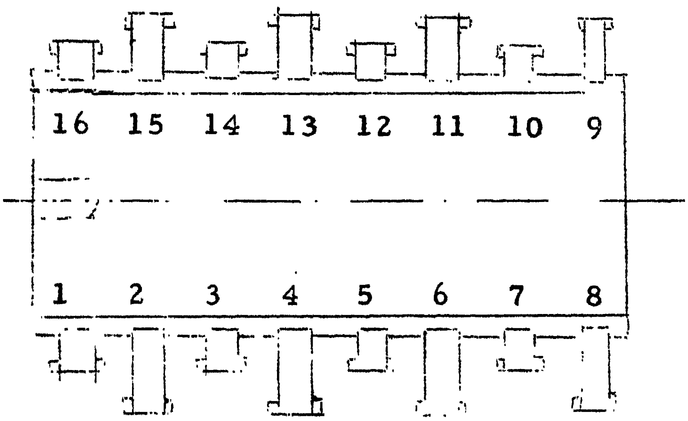
Transfer admittance at f_o=5.5 MHz.

y_f(typ.) = $|0.76|$ $e^{-j6°}$ mhos

APPENDIX III

SOME OF THE IMPORTANT DATA & CHARACTERISTICS OF TAA 700

Mechanical data



Top View

Characteristics

Measured at $T_{amb} = 25°C$; $V_p = 12$ V.

Video Amplifier

Input resistance (detector load)	R_{10-16}	typ.	2.7Kohms
Input capacitance	C_{10-16}	<	1 pF
Bandwidth (3 dB)	B	>	5 MHz.

Voltage gain	G_v	typ.	9.5dB
Video input voltage (peak to peak value)	$V_{10-16(p-p)}$	typ.	2V[1]
Video output voltage (peak to peak value)	$V_{12-16(p-p)}$	typ.	6V[2]

<u>Tolerances on video output voltage:</u>

I.C.processing spreads	$\pm\Delta V_{12-16}$	$<$	550mV
Temperature drift	$-\Delta V_{12-16}$	$<$	20 mV/°C[3]
Spreads over a.g.c. expansion (entire range)	$\pm\Delta V_{12-16}$	$<$	270 mV[4]
Black level at the output	V_{12-16}	typ.	5 V[5]

<u>Tolerances on the black level at the output:</u>

I.C.processing spreads	$\pm\Delta V_{12-16}$	$<$	300mV
Temperature drift	ΔV_{12-16}	$<$	7mV/°C[3]
Spreads over a.g.c. expansion (entire range)	$\pm\Delta V_{12-16}$	$<$	250 mV[4,6]
Variation black level at the output due to supply voltage variations	$\dfrac{\Delta V_{12-16}}{\Delta V_P}$	typ.	0.7
Available video output current (peak value)	I_{12M}	typ.	14mA[7]

Video blanking

Input voltage (peak to peak value)	$V_{11-16(p-p)}$		1 to 5V
Input resistance	R_{11-16}	typ.	1Kohms

A.G.C. circuit

Control voltage if amplifier	V_{4-16}		0 to 8 V[8]
Control Voltage tuner	V_{6-16}		0 to 7V[8]
Signal expansion for full control of i.f. amplifier and tuner		$<$	15%[8]
Keying input pulse (peak to peak value)	$V_{3-16(p-p)}$		1 to 5V[9]
Input resistance	R_{3-16}	typ.	1Kohms

Synchronising circuit

Sync.separator			see note 10
Control voltage line oscillator	$\pm V_{2-1}$	typ.	3V[11]
Output voltage vertical sync.pulse separator (peak to peak value)	$V_{15-16(p-p)}$	$>$	10V
Output impedance	R_{15-16}	typ.	2Kohms

<u>Notes</u> (1 to 11)

1. Negative going video signal (no pre-bias needed for the detector)

2. Video signal with negative going sync.pulse.

3. Because the integrated circuit reaches 95% of its final working temperature in 100 seconds, the temperature variations to be considered are those caused by the slower rise in cabinet temperature and by changes in room temperature.

4. Variation about a nominal condition, the i.f. being fully controlled and the tuner uncontrolled. The video signal increases and the black level decreases with increasing antenna signal.

5. Only valid if the video signal is in accordance with the CCIR standard.

6. To this must be added 0.7 ΔV_p, if operation of the a.g.c. causes a change in V_p.

7. The total load on pin 12 must be such that under nominal conditions $I_{12M} \leq$ 14mA.

8. These figures are obtained with a load impedance of 2Kohms for the i.f. control point (R4-16) and 1 Kohms for the tuner control point (R6-16). With these impedances the signal expansion for i.f. control and tuner control will be about the same. An increase of these impedance will

reduce the signal expansion. Lower values will redue the available control voltage and increases the dissipation of the integrated car circuit. Therefore, the minimum values must be restricted to 1.5Kohms for the i.f. control point and 750 ohms for the tuner control point.

9. The TAA 700 may be operated unkeyed but then point 3 must be connected to the positive supply line via a resistor of suitable value (e.g. 10Kohms). However, the following consequences should be borne in mind.

- The decoupling capacitors at the i.f. and tuner control points must be larger to prevent ripple voltages due to the vertical sync.pulses. In consequence the a.g.c. will not follow fast signal fluctuations (airplane flutter).

-Since the horizontal phase detector is designed to be keyed, unkeyed operation will result in the phase detector not operating as a frequency detector when the horizontal oscillator is out of sync. This considerably decreases the catching range.

10. The sync. pulse is sliced about 30% below top sync. level.

11. Required reference voltage $V_{2(p-p)}$ (sawtooth or differential line fly-back pulse)= 7V. For an oscillator reactance stage with a control sensitivity of 400 Hz/V this gives a holding range of about ± 1000 Hz. Because the phase detector is keyed a catching range of ± 700 Hz is obtained without affecting the noise immunity.

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